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EDITORIAL

EMERGENCY SURGERY

NECESSITY for prompt action differentiates emergency from elective surgery. In general, surgical emergencies arise in persons previously well and as such they receive medical attention without much delay. On the other hand, chronically ill patients who develop acute surgical conditions do not fare so well, for the urgency of their condition may be overlooked by the medical attendant, or a serious operation may be undertaken hastily without adequate preoperative preparation. The tendency to regard new complaints as trivial is not confined to the general practitioner, for attending hospital surgeons are just as prone to err. This state of affairs has given rise to the comment that the worst place for a peptic ulcer to perforate is in a hospital.

In the early days of the craft, surgical emergencies and operations were synonymous terms, but this association no longer exists with the passing of the period when the surgeon's training consisted simply of learning to operate. It was only when the curriculum began to include training in when, as well as how, to operate that decisions regarding operation were considered within the surgeon's province. It is, of course, now recognized that the surgeon's decision not to operate is just as important as the decision to operate, but this belated recognition has not always been freely given.

The Halsted system of surgical apprenticeships with its emphasis on pathology and its development of physiologic operative procedures based on animal experimentation has brought forth a concept of surgical problems in which the patient, not the operation, plays the major rôle. In this respect the present day surgeon fulfills Osler's requirement and truly is a physician who operates. He no longer is content to be simply an operator but insists on solving the purely non-operative problems of surgery, a task for which he is preëminently fitted by virtue of his adequate training.

The modern surgeon too has been quick to adopt the contributions of the pure scientist and laboratory worker and to apply discoveries in the basic sciences to everyday surgery. As a specific instance of this we wish to cite the recent revival of our interest in antiseptics. Modern surgery began with the introduction of antiseptics and progress since then has been founded on the principles of antiseptic surgery as evolved and taught by Lister. With increasing knowledge of bacteria the aseptic school of surgery has almost supplanted the antiseptic school. The pendulum has swung so far that at a recent symposium on the treatment of wounds only a single voice was raised in defense of antiseptics. The disrepute of antiseptics is due to their destructive action on the

living cell since with most antiseptics in common use bactericidal activity is proportionate to tissue toxicity. In a study of antiseptics, Dr. Frank Hartman, Director of Laboratories at the Henry Ford Hospital has produced a combination of antiseptic agents which closely approximates the ideal because of its high phenol coefficient and low tissue toxicity. This antiseptic, hexyl-chlor-m-cresol, has been subjected to extensive clinical application and has yielded results superior to those encountered with any of the commercial antiseptics.

The renaissance of surgery reflected in all branches of surgical practice is well exemplified in the modern management of surgical emergencies. The day has gone when patients are rushed into the operating room and subjected to immediate operation. Surgeons of that period, because of the emphasis laid on manual dexterity, placed all their faith in the operation alone and took too little cognizance of the patient's condition. A comparison of mortality rates then and now emphasizes this point. The low mortality rate of today does not necessarily indicate that the present day surgeon is a better operator, but it does mean that he takes better care of his patients.

Perhaps nowhere in the practice of medicine is the exercise of mature judgment founded on experience of more importance than in the handling of surgical emergencies, and yet it is common practice in most hospitals to relegate this responsibility to junior staff members. It is a tribute to present day training that in spite of this seeming paradox the mortality of emergency surgery has steadily decreased in the past decade. This improvement is due to an appreciation of the necessity for restoration of body fluids, glucose, sodium chloride, plasma protein, hemoglobin, vitamins C and K, and other important factors to a normal level, to realization of the importance of adequate supportive measures in forestalling and combating shock and to the more general use of local and in certain cases spinal anesthesia for these operations.

Emergency operations are at best hazardous undertakings. Most of them occur at night when the surgeon is often fatigued and when even in the best hospitals the operating room staff is not so alert as in the day time. Frequently assistance is inadequate, full equipment and supplies are not available and administration of the anesthetic is far from ideal. It is not surprising that the mortality for operations performed as emergencies is higher than for the same procedures carried out on a previously established schedule.

Surgical emergencies may be classified according to their urgency into three groups: Group I, in which immediate operation without preparation is indicated, as for example uncontrolled external hemorrhage or massive internal hemorrhage; Group II, which requires operation as soon as dehydration is controlled, as for example acute appendicitis, perforated peptic ulcer, strangulated hernia, etc.; Group III, when operation is best deferred until the patient's general condition is improved by adequate treatment, as for example appendicitis with general peritonitis, certain cases of acute pancreatitis, intestinal obstruction, etc.

Except for cases falling into Group I there is no indication for unnecessary haste in operating. Surgical intervention should be deferred until blood has been obtained for grouping and intravenous fluids have been administered. This delay will enable the surgeon to assess the patient's general condition and obtain a second opinion when the diagnosis is not entirely clear. Time spent in preparing patients for operation will pay big dividends in the form of lowered mortality and decreased morbidity. All these points and more have been emphasized over and over again by our contributors who have endeavored to make this volume thoroughly practical by avoiding controversial points and by presenting methods which they have found successful in their own practices.

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ORIGINAL ARTICLES

ANESTHESIA FOR EMERGENCIES*

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WHILE the general principles governing anesthesia for surgical emergencies are precisely the same as those for ordinary surgery, there are certain conditions present at these operations which have an important bearing on the choice and management of the anesthesia. These conditions are (1) lack of time, (2) the possibility of a full stomach, and frequently (3) the presence of shock.

1. From the very nature of things time is not usually available for all the preparatory measures usually considered advisable when deliberate surgery is concerned, such as complete history and physical examination, thorough laboratory work, and a period of rest in bed for sedation and hospital acclimatization, as well as measures designed to correct abnormalities or to improve the patient's condition, such as infusion or clysis, transfusion, and gastric lavage. Except in most pressing emergencies, however, such as asphyxia or severe hemorrhage, some sort of brief history may usually be obtained, perhaps from family or friends, a physical examination of sorts may be performed, and some laboratory data obtained, such as urinalysis and blood counts. Thus a fair idea of the patient's general physical status and of the presence of any abnormalities may usually be had. Infusions, even if not completed before the operation, may usually at least be started and can be kept running during operation, often to great advantage.

2. Even if operation does not take place for some time after the last meal, a full stomach may nevertheless be present. If the emergency arises within a short period (less than three hours) after the meal, whether the emergency is of a natural sort, such as acute appendicitis or strangulated hernia, or is of an accidental nature, such as an automobile or industrial accident or human violence (bullet or stab wounds), in either case digestion is usually stopped, and thus, even if operation does not take place till some hours later the stomach will usually be full of partly digested food.

The possibility of undigested food in the stomach should always be kept strongly in mind as this is one of the most important considerations in these cases, inattention to which may prove quite disastrous. Careful consideration should, therefore, be given to the character of the last meal and to the time elapsing from then to the occurrence of the emergency. It must always be remembered that it is this period of time and not the period to the time of operation which is so important. If there is any doubt about it, if, for instance, the last meal was not reasonably digestible, or if less than three hours elapsed thereafter before the emergency arose, it is safer to presume that at least some food is still present in the stomach.

The importance of this whole problem of food in the stomach can hardly be exaggerated, since it is a factor which may wreck and bring to naught an operative procedure otherwise well planned and successfully executed. For if the patient should vomit at a time when the throat reflexes which guard the larynx were sufficiently obtunded he might very well aspirate some

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of the vomitus into the lungs with the subsequent production of atelectasis or pneumonia, very likely with a fatal termination. It is this possibility which makes the question of food in the stomach of paramount importance in these cases.

When, therefore, after careful investigation there is still doubt that there may possibly be food left in the stomach an anesthetic should be chosen which does not obtund the protective throat reflexes. This means that local, regional, or spinal anesthesia is the anesthesia of choice, and that general anesthesia should not be employed if it is in any way possible to get along without it.

When local or regional anesthesia are suitable for the surgical procedure and give satisfactory operating conditions they are excellent. Such cases are most apt to occur in traumatic surgery of the extremities. Thus local anesthesia may be used for the reduction of simple fractures and regional anesthesia for localized trauma such as knife or bullet wounds. Field block is also excellent for scalp wounds. In abdominal operations local and regional anesthesia are usually unsatisfactory unless combined with a general anesthetic, and spinal anesthesia therefore becomes the anesthesia of choice. It is often also the best choice for operations on the lower extremities particularly if suture of tendons is involved. It is particularly indicated in operations for acute appendicitis not only because it lessens the danger of aspiration of vomitus but also because under it the danger of spreading the infection from the appendix to other parts of the abdominal cavity is reduced to a minimum. Under inhalation anesthesia the heaving abdomen and often the lack of complete relaxation make it difficult to keep infection localized but under spinal anesthesia the quiet abdomen and utter relaxation make conditions as favorable as they possibly can be for such localization. Unless contraindicated by the condition of the patient it is also the anesthesia of choice in strangulated hernia and intestinal obstruction. Not only does it lessen danger of aspiration as compared with general anesthesia but also it upsets the patient less and is followed by less nausea and vomiting. In our experience with these patients it has usually been followed by notably good recovery. With strangulated hernia, however, it is sometimes desirable to use a non-relaxing anesthesia such as gas oxygen, so that a gangrenous piece of gut may not fall back into the abdomen and be lost.

If spinal anesthesia is used for an operation for perforated gastric ulcer or for other abdominal operation in which infection is present and after which steep Fowler's position may be indicated, it is well to remember that if a 20 or 21 gauge spinal needle, such as is commonly used by most anesthetists, is employed, the patient will be almost sure to develop a very severe headache when Fowler's position is assumed. On the other hand, if a 24 gauge or smaller needle is used this will probably not occur even though Fowler's position is assumed shortly after operation.* Of course, due care must be taken when the patient is placed in this position to see that cerebral anemia does not occur. This can be immediately remedied, however, by lowering the patient's head.

Many surgeons and anesthetists question the propriety of using spinal anesthesia in perforations of the stomach or intestines because of the danger that the contractions of these organs caused by spinal anesthesia may squeeze further contents out into the peritoneal cavity, thus causing peritonitis. We have never felt that this danger was great enough to justify foregoing the other manifest advantages of this anesthesia.

In all this discussion of spinal anesthesia it is assumed that the administration is by a competent anesthetist who is thoroughly familiar with this particular form of anesthesia, for otherwise it may be quite dangerous. If such an anesthetist is not available it would probably be safer to use

* Sise, L. F. A method for the prevention of post-puncture headache in cases of low spinal anesthesia. *S. Clin. North America*, 19: 695–698 (June) 1939.

some other form of anesthesia. This precaution is quite important, since there are few methods of anesthesia in which safety is so dependent on the skill and experience of the one who administers it.

When for any reason the first choices of local, regional or spinal anesthesia cannot be employed in these cases, the second choices of gas-oxygen or gas-oxygen-ether* should be used. These inhalation anesthetics are less desirable than the first choices both as regards aspiration of vomitus and, with the exception of spinal anesthesia, as regards shock. For protection against aspiration it is the practice of some anesthetists when using these anesthesias to stop administering the anesthetic in the induction period so that the patient will recover and vomit, with the hope that the stomach will be emptied of any food that is in it and that full anesthesia can then be resumed with safety. This measure has its advantages, chief of which is its simplicity. It does not, however, ensure that the emptying of the stomach is complete and that vomiting cannot take place again later on. Also, the passage of vomitus through the throat renders it extremely acid. It is well known that the secretions of the throat may find their way into the lungs during any ordinary general anesthesia. Under ordinary circumstances these are quickly gotten rid of on recovery and appear to do no harm. But if they have recently been made strongly acid by the passage of vomitus with perhaps some small food particles left behind, it may well be that they are not so innocuous and that they may cause at least an irritative bronchitis and possibly atelectasis or pneumonia. It seems preferable, therefore, instead of trusting that vomiting will empty the stomach, to make definitely sure that it is empty by means of a thorough gastric lavage, if the circumstances are such that this is practical.

When the circumstances are such that gastric lavage cannot be done we prefer to intube the patient with an intratracheal airway. Induction should be rapid and anesthesia deep for intubation so that the patient will not vomit before intubation is complete. If in spite of these precautions he does vomit, the mouth and throat should be carefully cleaned by suction and the trachea inspected. If there has been no aspiration, intubation may be done, but if aspiration has occurred bronchoscopy should be carried out immediately, if the surgical condition is such that this is allowable, and any foreign material in the trachea or bronchi carefully removed by suction, after which intubation may be completed.

When the intratracheal tube has finally been placed in position the gas supply should be connected directly to it with a pressure of approximately 12 mm. of mercury in the breathing bag.

The patient is now safe from further danger of aspiration. The pressure in the breathing bag ensures that all inspiration takes place through the intratracheal tube and that none occurs in the space around the tube, the only space where aspiration could otherwise occur. Because of the pressure in the breathing bag, expiration through this space around the tube is much stronger and of larger volume than usual, so that aspiration becomes impossible. Intratracheal gas-oxygen is especially suitable for operation in injuries of the head, face, or mouth, but covers satisfactorily a wide range of other operations.

If during a general anesthesia, whether or not an intratracheal tube is in place, vomiting takes place if there is the slightest doubt that aspiration may have occurred bronchoscopy should be done immediately at the conclusion of the operation. This may well be done by the anesthetist. Anyone who is thoroughly familiar with intubation by direct laryngoscopy (as every anesthetist should be) can very readily learn bronchoscopy, and, as time is very important, his presence on the spot marks the anesthetist as the logical man for this procedure.

*Throughout this paper the word "gas" is taken to signify nitrous oxide, ethylene, or cyclopropane.

3. The effect of the presence of shock on the choice of anesthesia is in no way different from that in ordinary non-emergency surgery. It does, however, limit the choice of anesthesia still further, since any anesthesia such as spinal or ether, which tends to intensify it would probably be contraindicated. Under these circumstances, if local or regional anesthesia, the first choices, would be insufficient for the operation, resort must be had to the second choice of gas-oxygen or gas-oxygen ether as mentioned above. If the operation is abdominal, field block will be of considerable help by producing muscular relaxation at least at the immediate site of operation.

The anesthetist may well concern himself also with the treatment of shock when it is present, but such treatment has been so thoroughly covered elsewhere that it will not be considered here.

SUMMARY

While the general principles involved in anesthesia for emergency operations are identical with those for deliberate surgery, the conditions usually present in emergencies make much greater demands on the anesthesia and curtail the available number of choices while at the same time limiting the data from which a judgment of the choice must be made. These conditions are (1) lack of time for gathering data about the case and for preparing the patient for anesthesia and operation, (2) the probability of food in the stomach, and often (3) the presence of shock.

The presence of partly digested food in the stomach is a most important complication, which may lead to severe postoperative complications and even death unless properly handled. For this reason local, regional, or spinal anesthesia is usually first choice and intratracheal gas-oxygen or gas-oxygen-ether is second choice. Spinal anesthesia is extremely useful, especially when the operation is abdominal, but should be administered only by one thoroughly familiar with its use. Bronchoscopic examination and drainage are often useful and may be life saving, and may be done to advantage by the anesthetist.

If shock is present the use of spinal, or ether anesthesia is usually inadvisable and local, regional, or gas-oxygen anesthesia or a combination of these is to be preferred.

SHOCK*

A CONSIDERATION OF PREVENTION AND TREATMENT

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THE findings in shock are well known,[1] including pallor, sometimes with slight cyanosis; a cold, moist or sweaty skin; a rapid, regular, but thready pulse; rapid, usually shallow respirations; restlessness and an appearance of anxiety which may change to dulness and lessened sensitivity; thirst; a variable amount of nausea and sometimes vomiting. The temperature is usually subnormal, the blood pressure is low, or falling, the red count and hemoglobin may be low, normal or high, depending on the relation between the loss of whole blood and of plasma. Most important, there is a diminution in the effective volume of circulating blood.

The classical cause of shock is severe trauma in which large masses of tissue are crushed, often in association with fractures of long bones. Hemorrhage, whether external or concealed, if of sufficient quantity, leads to shock. Surgical operations, burns, freezing, intestinal strangulation, peritonitis and many so called "medical diseases" may be associated with the development of shock.

All cases of shock are not referable to one etiology and various classifications have been devised to distinguish them. Thus primary and secondary shock have been long used. Primary shock refers to the immediate collapse following injury, as contrasted with secondary shock which comes on after a variable interval following the trauma.

Primary shock has usually been interpreted as the immediate reaction of the nervous system to trauma similar to ordinary syncope, initiated by a peripheral vasodilatation, probably in the splanchnic area, with a sudden fall in blood pressure leading to unconsciousness. Primary shock often merges imperceptibly into secondary shock. The work of O'Shaughnessy and Slome[2] suggests that primary and secondary shock are different stages of one and the same process.

We have suggested a physiologic classification of acute circulatory failure, the different types being designated as hematogenic, neurogenic and vasogenic.[3] Hematogenic refers to those instances in which there is an initial decrease in the blood volume which is followed by vasoconstriction and a decrease in the output of the heart and subsequently by a decline in the blood pressure. The conditions associated with simple hemorrhage and trauma to muscles are examples of this type. The neurogenic type is associated with vasodilatation which is dependent on diminished constrictor tone as a result of influences acting through the nervous system. The blood pressure declines first and subsequently there is decrease in the blood volume and the cardiac output. The vasogenic type is associated with vasodilatation which is produced by agencies which act directly on the vessels. Histamine probably exerts most of its effect in this manner. Unfortunately, most instances of shock as observed in patients are complicated and may be combinations of the different types. For example, many different factors may enter into the development and maintenance of shock associated with

* From the Department of Surgery, Vanderbilt University. Aided by a Grant from the Division of Medical Sciences of the Rockefeller Foundation.

operations. Not the least of these is the fact that the patient is usually ill at the time that the operation is undertaken.

It has long been known that an important feature of shock is a decreased blood volume. The initiating factor in shock due to gross trauma is probably blood and plasma loss in and near the site of trauma.[4,5] Harkins and Roome[6] have measured the amount of swelling occurring in human traumatic injuries, finding amounts as high as 1500 c.c. of blood or plasma lost into the traumatized tissues in some cases. In less serious injuries, as the crushing of a hand or forearm, 600 c.c. of fluid was estimated to be lost into the tissues. They point out that such concealed hemorrhage and plasma exudation may reach considerable amounts without being suspected on casual examination. Secondary factors also operate to aid in the production of shock. These include pain, fear, cold, starvation or dehydration, anesthesia and preëxisting disease. Freeman[7] has suggested that these factors act by vasoconstriction to increase tissue anoxemia and capillary injury, with a resulting increase in plasma loss.

Shock will be considered from the viewpoints of prevention and of treatment. Obviously, there is of necessity some overlapping as prevention and treatment are often one and the same.

PREVENTION

The ideal objective to be sought for is the prevention of the full blown picture of shock. As the condition progresses, the changes taking place may become irreversible and treatment becomes of less avail. Much can be done in the prevention of shock, particularly in elective surgical procedures. Since dehydration, by reducing the amount of available fluid, is a factor in the development of shock, patients should have adequate fluids. Purgation before operation should be avoided because of the fluid loss that it entails. In the presence of diarrhea or vomiting, this fluid loss should be made good. Coller et al.[8] have pointed out that the chloride requirement can be satisfied by the parenteral administration of 0.9 per cent sodium chloride solution, equal in amount to the loss due to vomiting or diarrhea. In the absence of vomiting or diarrhea, the daily water requirement has been shown by Coller and Maddock[9] to average 3,500 c.c. per day. This may be given orally, subcutaneously, or intravenously, preferably by one of the former two routes. In the presence of diarrhea or vomiting this fluid requirement will be increased. Fluid loss during operation may be great, as Coller and Maddock[10] have shown. They found during operation and a four hour recovery period that a liter of fluid was lost in the average case, 70 per cent of this through the skin and lungs. In prolonged operations as much as 2 liters might be lost. Replacement of this fluid should be cared for. Holman[11] has suggested that patients receive 1,000 c.c. of 10 per cent glucose intravenously two hours before operation, in addition to fluids during operation. The introduction of blood is preferable to solutions of crystalloids if the operation is a protracted one and the loss of blood is great. By hypodermoclysis in the thighs, patients may be given from 750 to 2,000 c.c. of physiologic saline during the course of the usual operation, to guard adequately against dehydration.

The general nutrition of the patient, as well as salt and water must be considered. Holman[11] points out that the undernourished patient with a hypoproteinemia, in whom the vitamin store is low, is not in fit shape for the ordeal of an operation. He advises that in elective operations, patients should be placed for ten days on a high vitamin diet with the addition of concentrated vitamins, namely haliver oil 2 capsules t.i.d. for vitamins A and D; brewers' yeast powder, one heaping teaspoonful t.i.d. in fruit juice for the vitamin B complex; and the juice of four oranges and two lemons daily for vitamin C. For the anemic patient, liver, iron and concentrated vitamins are to be particularly stressed. Transfusions may be necessary,

with the aim to obtain a hemoglobin of 60 per cent, although Holman states that one occasionally will have to be satisfied with 40 per cent.

The recent discovery of the rôle of vitamin K in the production of prothrombin and its relation to the hemorrhage occurring in jaundice offers an excellent opportunity for the prevention of shock due to hemorrhage which is so often seen postoperatively in these patients. Quick[12] has devised a test for prothrombin deficiency, reduction of which to 20 per cent of normal is apt to be followed by bleeding. Snell, Butt and Osterberg[13] have reported excellent results from the administration of vitamin K in combination with bile salts, in the prevention of hemorrhage in jaundiced patients, and in the treatment of active bleeding. Vitamin K and bile salts are given preoperatively, until the prothrombin is elevated to normal. Where bleeding is present, transfusion is indicated to be followed by the administration of vitamin K and bile. They point out that the greatest danger from the hemorrhage occurs from the third to ninth day postoperatively, so that treatment should be continued after operation.

Attention to careful hemostasis and avoidance of unnecessary trauma during the performance of operations will aid in the prevention of shock. Gatch and Little[14] measured the amount of blood lost during operations, finding that 50 to 300 c.c. might be lost in abdominal operations, and with such procedures as mastectomy or thyroidectomy the amounts might be as great as 400 to 700 c.c. Such a blood loss, combined with the other shock-producing influences of a major operation, may play an important rôle in the fall in blood pressure and should, therefore, be kept at a minimum.

The patient's body heat should be conserved during operations. Considerable heat may be lost by evaporation occurring from large area of peritoneum or muscle which may be exposed, particularly when moist sponges or packs are used. The evaporation of water from the surfaces may result in a great loss of heat unless care is taken to see that warm sponges are used. The room should be comfortably warm. Excessive heat tending to cause marked sweating by the patient is to be avoided.

The choice of the anesthetic agent must be considered in relation to shock. Ether anesthesia has a greater tendency to depress the blood pressure than nitrous oxide-oxygen. In long, tedious operations where relaxation is necessary, the use of ether, by minimizing the amount of trauma necessary, may outweigh its depressing action on the blood pressure. It is desirable that a high percentage of oxygen be used in combination with ether.[15] The dangers of anoxemia have been emphasized by Hartman and McClure.[16] Different viewpoints are held in regard to the use of spinal anesthesia when shock is feared.[2,17] Burch, Harrison and Blalock[18] have shown that the tolerance to hemorrhage is less under spinal than under ether anesthesia. Local anesthesia should be used whenever it meets the requirements.

In operative procedures of great severity, or when the patient's condition leads one to suspect that some degree of shock may follow operation, a blood donor should always be available. The cross agglutination tests should have been performed, so that if blood is needed, it can be given at once. A decline in blood pressure to below 90 after operation should indicate the necessity for blood transfusion. In fact, many believe that every operation of the magnitude of a thoracoplasty, for example, should be followed by a transfusion.

Good postoperative care will aid in the prevention of shock. Following operation, warm dry gown and blankets should be applied. Excessive sweating, because of of the fluid loss, should be avoided. An adequate fluid intake, either oral or parenteral should be maintained, as noted before. Edema should be watched for. Coller, Dick and Maddock[18a] found that in sick patients receiving intravenous

fluids, usually 3,500 c.c. daily, when 0.9 per cent saline or 5 per cent glucose in saline was given, there was an increase in body weight due to fluid retention, often with dependent edema. When glucose in distilled water was given, the excess water was excreted.

Wangensteen and Paine[19] and Miller and Abbott[20] have devised means for decompressing the distended intestinal tract. In instances in which strangulation is not feared, the operation can be made easier both for the surgeon and the patient if the distention is relieved. Frequently, it will be found that an operation is not necessary. During the time that the distention is being treated, the general condition of the patient may be improved by fluid administration, etc.

Fractures should be immobilized in temporary splints, preferably before the patient is transferred from the scene of the accident to the hospital. Two purposes are served by splints. Pain is decreased and further damage to the soft tissues by bony fragments is prevented.

A vigorous effort should be made to control diabetes in patients in whom an operation is contemplated. Patients with Addison's disease should receive large doses of cortical extract prior to operation.

TREATMENT

As a preliminary to treatment, one should determine if possible the principal cause for the development of shock. This is important because all declines in the blood pressure are not due to the same cause and are not of the same significance. For example, a decline in blood pressure associated with vasodilatation which may follow an operation on the central nervous system is not of as grave significance as a similar decline in blood pressure accompanied by vasoconstriction which may follow simple hemorrhage or trauma to large masses of tissues. In the latter condition, the blood volume is markedly diminished and the supply of blood and oxygen to the tissues is greatly decreased. For this reason, if immediate treatment is not carried out, irreparable damage to the tissues is apt to occur. Furthermore, since vasoconstriction is already present, the use of drugs which cause constriction of the vessels can do little if any good and may result in harm. The circulating blood volume is reduced and attempts should be made to augment it. On the other hand, if the decline in blood pressure is associated with vasodilatation rather than vasoconstriction and if the blood volume is not reduced greatly, the use of vasoconstrictor drugs may result favorably. Furthermore, the decline in blood pressure is tolerated better since the blood volume may be essentially normal and the supply of blood and oxygen to the tissues not so greatly reduced. It is important to bear these differences in mind in evaluating the effects of therapy.

In the care of traumatic injuries, it is important to estimate the degree of injury, so that if shock is to be expected, no time will be lost in beginning its treatment. Where multiple fractures or injury of large amounts of soft tissue, either with or without external hemorrhage, are present, shock is to be expected, and arrangements should be begun at once to obtain a donor for blood transfusion. Hemorrhage should be arrested as quickly as possible. This can usually be done by a compression bandage or digital pressure. Tourniquets must be used with a good deal of circumspection. If an extremity is hopelessly destroyed, a tourniquet may be applied, left on, and amputation done above the tourniquet, without removing it. But if the member is to be saved, a tourniquet should not be applied unless for a very brief period. As Wilson and Roome[21] have emphasized, the release of a tourniquet which has been in place for some time results in a marked fall in blood pressure, due to fluid loss into the extremity. This is undoubtedly due to vascular injury from anoxemia, and in an extremity already traumatized, the application and release

of a tourniquet further devitalizes tissue, leading to greater plasma loss.

The patient brought in in shock is usually chilled, and should be warmed immediately, warmed blankets being most satisfactory. Hot water bottles and other methods are available, but care must be taken not to burn the patient. Unless head injuries are present, morphine should be given to relieve pain and anxiety, ⅙ to ¼ gr. usually being sufficient for the average adult. The use of large doses sufficient to cause respiratory depression should be avoided, particularly if an operation under general anesthesia may be necessary. For the restlessness associated with head injuries, sodium phenobarbital injected intramuscularly may be given cautiously—gr. 1½ to 3 as necessary.

When these measures have been applied, it will usually be possible to determine the patient's condition both from the blood pressure and general appearance. The patient who appears quite deeply shocked when first brought to the hospital may improve very greatly when warmed and comfortable. However, when the blood pressure remains low, further treatment must be started. Wangensteen[22] has suggested the following limits: A systolic blood pressure of 100 or less indicates potential shock. When the pressure is 90 or less, actual shock is present, and energetic treatment is to be instituted. At the critical level of 70 mm. Hg., inadequate flow of blood is afforded the vital centers, and when continued for several hours, will result fatally, regardless of treatment. Our aim then should be to prevent the continuation of a low blood pressure with its circle of vasoconstriction, tissue anoxia and fluid loss through the small vessels. This can be done by increasing the blood volume. The most satisfactory substance is whole blood transfused by direct or indirect method, after proper typing and cross agglutination tests. The amount to be given will depend upon the circumstances. The average sized donor may give 500 to 750 c.c. of blood without ill effect, and the patient in moderate shock should receive this amount at once. Patients in severe shock, whether from external or concealed hemorrhage, will need more blood, perhaps requiring several large transfusions. The amount will necessarily depend on the patient's reaction. When the blood pressure has been raised to above 100 mm. Hg., the patient probably has a satisfactory blood flow and blood pressure, but with very little reserve to withstand further trauma, such as operative procedures. When it is feasible, direct transfusion is preferable to indirect.

Gum acacia, 6 per cent in 0.9 per cent saline, was recommended in the treatment of shock in 1917 by Bayliss. Acacia, being colloidal, is held in the blood stream, while crystalloids have only transitory effect due to rapid loss through the vessel walls. A 6 per cent acacia solution in 0.9 per cent saline may be used as a temporary measure in the treatment of shock until blood is available for transfusion. It is probably better not to give more than 500 c.c. of acacia to any one patient because of possible ill effects. Severe and fatal reactions have been reported by Studdiford[23] following its use. A large proportion of the acacia is deposited in the liver in experimental animals, resulting in damage to carbohydrate and serum protein metabolism.[24] Good, Mugrage and Weiskittel[25] have reported satisfactory results with acacia in an average dose of 500 c.c. and not more than 1,200 c.c. Reactions occurred in 10 per cent of the patients. It is our impression that acacia should never be used if blood is available.

In shock due to trauma with resulting injury to many capillaries, solutions of isotonic saline or glucose given intravenously must be used with care. Such solutions raise the blood pressure for only short periods while they stay in the blood stream. Experimental observations[26] have shown that on leaving the vessels, protein is carried out along with the fluid, further decreasing the plasma concentration and volume. These findings have been con-

firmed on patients by Minot and Dodd[27] and by Gatch.[28] It seems quite definite that large volumes of solutions of crystalloids given intravenously in the presence of capillary damage may result in harm.

The patient in shock should not be subjected to surgical procedures other than absolutely necessary ones until the shock has been controlled. The anesthesia, trauma and loss of blood attending operation will further reduce the blood pressure, and jeopardize the patient's chance of recovery. The possible exceptions to this rule are cases in which concealed hemorrhage is suspected, as bleeding into the pericardium from a penetrating wound, rupture of the spleen, liver or kidney or ruptured ectopic pregnancy. In these instances the advantages to be gained in arresting hemorrhage by immediate operation will have to be balanced against the hazards of operating with the patient in shock.

In such cases, where large amounts of free blood may be found at operation, autotransfusion may be used, and may prove lifesaving, particularly if no blood donor is available. The blood is aspirated or may be scooped out with the hands into a sterile container in which 50 c.c. of 2.5 per cent sodium citrate is placed for each 500 c.c. of blood. The citrated blood is then filtered through several layers of gauze to remove clots, and re-infused into the patient's veins. Watson and Watson[29] report that in ectopic pregnancies, from 500 to 1,600 c.c. of blood may be recovered—a valuable amount to be saved for the patient, which may mean the difference between an adequate blood pressure and fatal shock. They recommend autotransfusion for ruptured ectopic pregnancy, injuries of the liver or spleen, and in hemothorax or hemopericardium. The wisdom of using autotransfusion in an injury of the liver is questionable. Lockwood[30] used this method in a splenectomy for Banti's disease, in which 750 c.c. of blood was recovered from the spleen and reinjected into the circulation. Obviously autotransfusion cannot be used in abdominal injuries where the gastrointestinal tract has been perforated, contaminating any blood in the peritoneal cavity. When blood has been present in the body cavities for some time, hemolysis may occur, leading to reactions. Such blood should not be used, if possible.

The establishment of blood banks in large hospitals should make transfusion much more readily available, but technical problems and the limited time which blood may be stored before hemolysis limit its use to larger hospitals. The same difficulties hold true for the use of placental blood. Regarding the use of preservatives, Scudder, Drew, Corcoran and Bull[31] recently stated, "Of the many preservatives used, none tested prevented the diffusion of potassium from cells. In several hemolysis was slower and in one it did not take place at all, yet the diffusion of potassium was not altered. The remainder showed definite hemolysis; in some it started as early as the fifth day. All this illustrates the inadequacy of present methods of storage."

Preservation of serum by the "lyophile" process[32,33] allows the collection and preservation of human serum without alteration of its characteristics. The experimental results of Bond and Wright[34] and of Mahoney[35] on the use of preserved plasma in shock due to hemorrhage or trauma are very encouraging. Although such plasma lacks the oxygen carrying capacity of whole blood, in many forms of shock, notably in burns, hemoconcentration is present, indicating the need for plasma only. A quickly available source of plasma such as lyophile serum would obviate some of the difficulties of blood transfusion. However, such plasma retains its agglutinins and would require typing. Ravdin[36] states, "The frequency with which reactions have occurred following the injection of lyophile serum given in concentrated or normal form, makes us hesitate to suggest the more general acceptance of this material." Cost of obtaining and preparing preserved plasma will probably limit its use.

The use of ascitic fluid as a blood substitute has been suggested by Davis and White,[37] Choiser and Ramsey[38] and has been used clinically by Davis and Blalock.[39] The latter point out that ascitic fluid is plentiful, cheap and can be kept for long periods without preservations and without deterioration. Its protein content is 2.0 to 3.19 per cent or 28 to 45 per cent of the concentration in blood plasma. Although not ideal, such a protein content should be superior to the use of saline or glucose. The authors' use of ascitic fluid in human cases of shock was limited, but heterologous and homogenous infusions had been given in ten patients, with two hyperpyrexial reactions. Ascitic fluids also contain agglutinins, and must be of the correct blood group.

In hospitals, even though they may be small, it is often possible to have blood donors available by the routine blood typing of convalescent patients who are in good physical condition. Where blood is urgently needed for a patient in shock, these convalescents may be willing to act as donors.

In the prevention and treatment of shock due to burns, tannic acid[40] is of great value. It is debatable whether its greatest benefit consists in a reduction in the loss of plasma, a lessening of the chance of severe infection or a diminution in the absorption of toxins. Bettman[41] has advocated the tannic acid silver nitrate treatment of burns. He points out that in serious burns, 60 per cent of the fatalities occur in the first twenty-four hours, nearly all of these from traumatic shock. The combination of tannic acid and silver nitrate is of superior value, he states, because of the almost immediate stopping of fluid loss from the burned surface. There is a quick cessation of pain, and a minimizing of shock. The danger of infection is lessened by the early drying of the tan. In the use of tannic acid-silver nitrate, the patient receives a narcotic and 5 per cent tannic acid may be applied on cotton swabs or by the use of a spray. With extensive burns, the patient may be placed in a tub of warm water as advocated by Wells,[42] containing enough tannic acid to give a muddy appearance to the water.

The following is the routine advocated by Blackfield and Goldman:[43] In the tub, all blebs and loose tissue are removed gently by means of sterile forceps and scissors. The surrounding skin is cleaned with green soap and water. The bath is changed as often as is necessary to dispose of the debris. The débridement and cleansing of the burned area usually require sixty to ninety minutes. At the end of this time, the patient is dried with sterile towels. The burned areas are then touched a number of times with gauze soaked in 10 per cent silver nitrate. The patient is placed under a cradle on sterile sheets. Several times a day for the first few days, a 1 per cent aqueous solution of gentian violet is applied to the tanned areas. By this means, small fissures or other areas which might become moist remain dry. If the patient is unable to take fluids by mouth, they should be given parenterally. Glucose 5 per cent in 0.9 per cent saline may be given intravenously. When shock is present, with marked hemoconcentration, transfusion of plasma or whole blood is indicated. The use of large amounts of saline or glucose[26,27,28] under these conditions results in the further "washing out" of plasma proteins from the blood stream and is to be avoided. McClure and Allen[44] and Harkins[45] have written excellent reviews on burns.

In secondary traumatic shock in which the blood volume is markedly reduced, the use of vasoconstrictor drugs such as adrenalin and ephedrine is not indicated. A low blood volume is the cause of the low blood pressure, not peripheral dilatation. The use of vasoconstrictors only increases the anoxemia of the body tissues with further loss of fluid from vessels.[7] Similarly digitalis drugs are not indicated, because the heart is not at fault.

The use of oxygen by inhalation has received little attention in the treatment of

shock. Although the oxygen content of the arterial blood is normal, that of the venous blood is greatly decreased. The inhalation of oxygen, increasing its partial pressure in the lung, would result in an increased amount dissolved in the plasma, and an increase in oxygen available to the tissues. The use of oxygen has been suggested by Yandell Henderson,[46] but unfortunately has been but little used clinically. To be effective, oxygen must be given with a nasal catheter or face mask or oxygen tent. Mere blowing of oxygen in the patient's face with a funnel is of little value, since it does not effectively increase the oxygen in the alveolar air. The use of the Boothby mask will simplify and render less expensive the administration of oxygen. It would seem logical to use oxygen inhalations in the treatment of traumatic shock, at least until the blood volume could be restored, carrying the patient over a critical period.

CONCLUSIONS

The points which should be emphasized include the following: All instances of shock are not explainable by one theory and such attempts result only in confusion. The most fundamental abnormality in shock is a disproportion in the size of the vascular system and its contents. This may be due to a marked decrease in the blood volume or to an increase in the size of the vascular system or to both. Progress in the prevention of shock has been greater than improvements in methods of treating the fully developed condition. Many of the points to be borne in mind in attempts to prevent shock have been mentioned. If one is allowed to generalize, perhaps the most important point is that an attempt should be made to restore to normal a decline in the blood volume before this is reflected by a significant decline in the blood pressure. This is best accomplished by the use of whole blood or blood serum. A prolonged decrease in the blood volume and blood pressure results in irreparable damage to the tissues and even the repeated transfusion of whole blood may not result in a sustained improvement. The dangers associated with the intravenous injection of excessive quantities of fluid other than blood in the presence of gross capillary damage have been mentioned.

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MAINTENANCE OF FLUID BALANCE*

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IN previous discussions of fluid balance[1,2,3] emphasis has always been placed upon individualizing the treatment to fit the needs of the patient, and further experience has more firmly established the soundness of this view. If a patient can take fluids by mouth there is generally no problem concerning the maintenance of a good fluid balance, and much of the material in this article has no bearing on such cases. Unfortunately often in emergency situations, for one reason or another, the patient cannot take fluids by mouth and the proper parenteral therapy is in the hands of the physician.

Emergency surgery commonly involves patients who are well up to the time of an acute trauma, and there are often no long standing deficiencies to deal with. In traumatic injuries, shock is of rather common occurrence and its prevention and treatment have been well discussed in the preceding article by Cressman and Blalock,[4] who, among other things, point out the dangers of administering large amounts of glucose or saline solutions when shock is present. This will be referred to later, but it here serves well to point out that the administration of fluids in emergency situations requires thought based on facts if one is to select the proper kind and amount of fluid to give.

Considering the kind of fluid to use, the choice is between the saline and glucose solutions, and the important point is that there is possible harm with the use of the saline and practically none with the glucose. The relation of sodium chloride to edema is common knowledge and yet several liters of physiologic saline or Ringer's solution may be given daily to patients who can ill afford the edema of salt on top of the edema of trauma. Accordingly, a few references to this possible harmful effect of saline solutions are in order.

SALINE SOLUTIONS

White, Sweet, and Hurwitt[5] studied the water balance of neurosurgical patients in order to be able to maintain them in a slightly dehydrated condition. In their article they state that "edema from too much salt solution is a very real danger. For this reason we recommend limiting the use of glucose in saline to the period of operation, during which there is a considerable loss of sodium chloride. Thereafter, fluids can usually be taken by mouth in adequate volume by neurosurgical patients. Saline solutions should only be used when the serum electrolytes are seriously depleted by prolonged vomiting or diarrhea, and then in limited amounts." In their summary White, Sweet and Hurwitt[5] state: "postoperatively fluid must be replaced much more accurately in neurosurgical than in general surgical patients. While the latter may be given a moderate excess of fluid with impunity, a slightly deficient state of hydration is safer after operations on the brain, in order to minimize cerebral edema. In the absence of vomiting or diarrhea, 5 per cent glucose in distilled water appears to be a better solution for prolonged intravenous administration than when combined with normal saline, because the addition of saline increases the risk of edema." This reasoning holds equally well for patients with cranio-

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cerebral injuries. Temple Fay[6] has long been an ardent supporter of dehydration therapy for such patients.

Beard and Blalock[7] studied the composition of the blood of dogs undergoing continuous trauma to the intestines when no fluid was injected and when fluid was injected continuously. A copious weeping of fluid from the peritoneal surface resulted from the trauma. This fluid had the same protein content as that of the blood plasma, the result being a loss of protein and therefore a diminished osmotic pressure of the blood. The effects of the injection of various fluids on the reduced protein content of the blood of these dogs, which were in shock, is most important. With the continuous injection of 0.9 per cent salt solution there was a decrease in the total volume of blood plasma and a marked reduction in the percentage of protein per unit volume of serum, the calculated entire amount of protein in the blood stream being generally one-half of the original values. It was the impression of Beard and Blalock[7] that if the injection of salt solution was stopped the blood pressure of the animals declined more rapidly than if no fluid had been introduced. With 3.0 and 6.0 per cent saline solution the results were essentially the same. From these experiments there is little to expect from the treatment of shock due to blood plasma loss by the use of physiologic saline solution. Beard and Blalock state "that they do not mean to imply that if a patient is in shock as a result of an injury and no donor is available that saline or similar solutions should not be injected. However, in the absence of a favorable response in blood pressure after a considerable amount of solution had been injected, almost certainly the further administration of the same fluid intravenously would diminish the chances of recovery."

Another warning concerning too much salt solution arises from a study by Jones and Eaton[8] on postoperative nutritional edema. Their thirty-four patients were all seriously ill, chiefly with lesions of the gastrointestinal tract, producing anorexia and undernutrition. Clinical edema was present in twenty-six of the patients, five had definite edema of the lungs, and eight on whom a gastroenterostomy had been done were considered to have edema of the stomach, of the gastroenterostomy stoma or of the adjacent intestine sufficient to produce partial obstruction at the stoma. Among the several factors thought to be responsible for the edema was the administration of excessive amounts of water and salt.

Jones, Eaton and White[9] then produced edema in cats and considered the factors responsible to be important in the following order: nitrogen starvation, general malnutrition, sepsis, the administration of excessive amounts of water and sodium chloride, serous drainage, major surgical procedures and general anesthesia. Mecray, Barden and Ravdin[10] showed experimentally in dogs that obstruction at the pylorus and at gastroenterostomy stomas could be produced as a result of edema incident to low plasma proteins and that gastric emptying time improved as the proteins increased. Their study emphasized that while edema is clinically an observation of excess fluid in the subcutaneous tissue, it is but an external manifestation of a general process with very definite harmful effect on internal organs.

The ease with which salt solutions are retained by seriously ill surgical patients was further demonstrated by Coller, Dick and Maddock,[1] who provided intravenously about 3500 c.c. of fluid daily to their patients under investigation, using 5 per cent glucose in either physiologic saline or Ringer's solution. At present in their patients selected for study, many seriously ill surgical patients have one or more of the important features setting the background for the retention of water, that is, nitrogen starvation, general malnutrition, sepsis, serous drainage, hemorrhage, impaired hepatic or renal function. But even with these it takes water and sodium ions for the edema to develop,[11,12] and it was the

impression of Coller, Dick and Maddock[1] that an excess of saline solution had been the precipitating factor in patients seen by them with postoperative edema. In their study group, twelve of the thirteen patients receiving salt solution retained water and gained weight although they were receiving insufficient calories and should have lost weight.

This common error of giving excessive amounts of salt solution to seriously ill patients when sodium chloride is not needed, is one to avoid. It is thoughtless as to the requirements of the patient; the excess amount of salt administered may easily amount to from 30 to 50 or more grams which must be excreted by the kidneys; and finally, the edema fluid is known to impair various functions and be harmful. The surgical staff may well feel guilty in some instances when patients come to autopsy with water-logged tissues.

The discussion so far on saline solutions has pointed out their possible harmful effects. However, everyone realizes that saline solutions must be given to some patients, but they are essentially for patients who have or have had abnormal losses of fluids containing sodium chloride. The most serious of these abnormal losses occur through severe diarrhea, dysentery, and vomiting. The first two are uncommon among surgical patients, while vomiting is the most frequent form of losing substantial amounts of body electrolytes. Other losses from the gastrointestinal tract may occur through biliary or intestinal fistulae, and recently there has been added the valuable therapy of continuous gastroduodenal suction.[13] When appreciable amounts of body electrolytes, chiefly sodium and chloride ions, have been lost through any one of these channels, they must be replaced. Evidences of even moderate deficiency are lethargy, depression, weakness, fatigue, anorexia, nausea, dehydration, drowsiness and stupor. With marked hypochloremia several patients at the University Hospital[14,15] and elsewhere[16] have shown the complete clinical picture of shock. The problem is how to restore sodium chloride adequately to these patients without giving too much salt.

At the University Hospital an attempt has been made to keep saline solution therapy on a simple basis, which on repeated studies has been shown to be as accurate as possible and still practical. The problem is divided into two groups, the first covering patients who are in the hospital and while under observation are losing important amounts of electrolytes through vomiting, gastroduodenal suction, intestinal or biliary fistulae, etc. The second group is composed of those patients who lost their sodium chloride before entering the hospital and on admission are found, after blood chemistry studies, to have low chlorides. There is, of course, some overlapping of these groups, since a patient who has been vomiting before admission to the hospital, may continue to vomit while in the hospital, but then the two methods of treatment are simply combined and both used as needed. They can be considered as follows:

Patients losing important amounts of gastrointestinal secretions while in the hospital have these losses measured. This is not difficult. Bile drained from the common duct or gall-bladder through tubes is readily collected in bottles. Suction is applied to intestinal fistulae and the drainage collected in siphon bottles. Patients who vomit more than once or twice have a Levine tube inserted through the nose and gastroduodenal suction started, and the amount of fluid withdrawn is readily measured. Also, the use of this gastroduodenal suction which has been shown by Wangensteen and his associates[13] to be so effective in intestinal obstruction, is applied to many patients to forestall vomiting or to keep the stomach and intestines decompressed after gastric and intestinal or other operations.

There is thus a frequent need for replacing daily abnormal losses of sodium chloride. Our treatment is based upon the fact that there is less of this salt in the gastro-

intestinal secretions lost than in an equal volume of physiologic saline or Ringer's solution. Data showing the sodium chloride concentrations in the various fluids are presented in Table I, from which it is

Table I
CONCENTRATION OF SODIUM CHLORIDE IN VARIOUS FLUIDS

	Variation in NaCl Concentration Gm/L	Average NaCl Concentration Gm/L	Reference
Vomitus	1.2–6.2	3.3	Dick, Coller and Maddock[17]
Gastroduodenal drainage (Wangensteen suction).	1.9–7.9	5.7	Bartlett, Bingham, and Pedersen[15] (Analysis of 100 twenty-four-hr. specimens)
Hepatic bile	3.5–6.4	5.1	Bartlett, Bingham and Pedersen[15] (Analysis of 30 twenty-four-hr. specimens)
Intestinal fistula drainage.	3.1–6.6 4.7–7.9 3.0–8.8	5.2	Bartlett, Bingham and Pedersen[15] Welch et al.[18] Karr and Abbott[19]
Diarrheal stools	3.7–5.2	4.3	Bartlett, Bingham and Pedersen[15]
Physiologic saline solution		8.5	U.S.P.
Ringer's solution		9.0	University of Michigan Hospital
Ringer's solution		7.0	Abbott's Laboratories

apparent that if a patient has a liter of gastroduodenal drainage a liter of physiologic saline or Ringer's solution will replace the water and more than the sodium chloride loss by a fair margin. This volume-for-volume rule is the replacement method used at the University Hospital in such cases. In actual performances two other ideas are incorporated into the procedure. The first is that when gastroduodenal suction is being used, a liter of Ringer's solution is given during the first twenty-four hours, in this way lessening an initial drop in plasma chlorides during this period.[14,15] For the second twenty-four hours the amount of Ringer's solution given equals the amount of gastroduodenal drainage for the first day, and this volume-for-volume replacement continues with the addition of the second idea, which is that a minimum of 500 c.c. of Ringer's solution is given daily, even if the drainage for the preceding day is less than this amount. It has been found for general surgical patients having gastroduodenal tube drainage, biliary and intestinal tube drainage that satisfactory plasma chloride and carbon dioxide combining power levels can be maintained by this seemingly rational procedure.[14,15,20]

For the second group of patients, those with low plasma chlorides when first encountered, the clinical formula[14,15] for restoring sodium chloride is used. This formula states that: for each 100 mg. that the plasma chloride level needs to be raised to reach the normal (560 mg. per cent) the patient should be given 0.5 Gm. salt per kilogram of body weight. Examples of the use of this formula in three hypothetical cases are given in Table II. Studies have

Table II
USE OF CLINICAL FORMULA FOR CORRECTING SODIUM CHLORIDE DEFICIENCY

Wt. of Patient, Kg.	Initial Plasma Chlorides, Mg. per 100 C.c.	Calculation of NaCl Needed, Gm.
60	460	$0.5 \times 60 = 30$
60	410	$1.5 \times 0.5 \times 60 = 45$
60	360	$2.0 \times 0.5 \times 60 = 60$

been continued on the use of this formula in a large series of general surgical patients, determinations being carried out on the plasma chlorides, plasma carbon dioxide combining power, fluid intake and output, urine chloride excretion, gastrointestinal tract and other fluid chloride losses, and changes in the patient's weight. From these studies several facts are apparent. First and most important is that the clinical formula provides enough salt to restore the plasma chlorides to normal. All patients, however, do not handle the provided salt in a normal manner. The best response, which is a prompt return of the plasma

chlorides to normal and an appreciable excretion of chloride in the urine, is obtained by patients who have not been sick very long but who have suffered a recent or acute loss of electrolytes, as through acute intestinal obstruction or a recent period of prolonged vomiting from any cause. The second group of patients with depleted chlorides often fail to have their plasma chlorides return to the expected level, and either excrete some of the salt given or add it to their body with water and gain weight. These patients generally have had a long standing illness associated with sepsis or general malnutrition or any one of the other factors previously mentioned as predisposing to the retention of water. Carcinoma of the gastrointestinal tract is one of the rather common initial lesions among these patients. Repeated case analyses have shown that giving more salt than the formula calculation fails to increase the plasma chloride level materially and simply adds to the retention of water, as often shown later by evident subcutaneous edema and ascites. In the most recent studies[20] it was found to be definitely a mistake to give more salt.

This failure of the plasma chlorides to come up to the level of normal individuals in some instances when disease is present has been noted before. McLean[21] found that the average renal threshold for chlorides in fever was 542 mg. and in diabetes mellitus 512 mg., instead of his average of 562 mg. per 100 c.c. of plasma found for normal individuals. Davidson[22] found that plasma chlorides in burned patients often remain well below normal despite a good daily intake of sodium chloride. The reasons for these alterations are not clear, but in the University Hospital patients[15,20] it was the rule that if they improved in general and began to eat, then the abnormally retained salt readjusted and the plasma chlorides approached normal. The clinical formula has been found to be usable by the general staff members of the University Hospital, and along with the volume-for-volume rule has sufficed to provide adequate amounts of salt for patients needing salt and at the same time has avoided the dangers of excess administration.

Besides the failure to recognize that postoperative edema is frequently initiated by too much salt solution, there are two other reasons why in the past the danger from salt solution has not been more apparent. One is that intravenous fluids are often only needed for one or two days and then the patient is able to take water by mouth. If there had been any retention of fluids as a result of the salt solutions, the administration was for too short a time for it to become apparent. The second reason is that patients who do not have the factors predisposing to the retention of water—general malnutrition, sepsis, etc.—do not retain fluids when given salt solution[1] but excrete the salt and a fair volume of urine just as is done within limits by normal individuals.[23] There are many patients not seriously ill who receive fluids parenterally for a day or two, patients whose general condition was good up to the time of the operation and is good after the operation, but who are temporarily upset and need to be given fluids other than by mouth. The excretion of the sodium chloride is an unnecessary load on the kidneys and the salt solution is a poor choice of fluids for these patients. As emphasized, the real danger from salt solution is with the seriously ill patient and facts and ideas on this subject have been presented in previous paragraphs.

In this discussion the need for sodium chloride has been considered in terms of chloride. This works out practically because in surgical patients significant losses of electrolytes generally occur through loss of fluid from the upper part of the gastrointestinal tract. In such instances the loss of chloride ions is generally greater than, and only occasionally equalled by, the loss of sodium ions. Since in correcting a deficiency of these ions the solutions commonly used, physiologic saline or Ringer's solution, have an equal number of both

ions,* the deficiency of both can be corrected. Gamble[24] has emphasized that with a good supply of available water the kidneys can be depended upon to excrete the less needed ion.

An occasional case is encountered among surgical patients in which the loss of sodium has been appreciably greater than the loss of chloride ions. Two recent examples were, first, in a patient with marked drainage from an ileostomy done because of chronic ulcerative colitis, and secondly, in a patient with prostatism and severe renal damage. In both these patients a solution providing an excess of sodium, Hartmann's[25] sodium lactate, was given. One must be on the watch for, and understand, these less common lesions in surgical practice.

WATER AND GLUCOSE

Glucose solutions are valuable because they supply readily available water and carbohydrates. Water comprises 65 per cent of the total body weight and most living organisms are dependent upon a rather frequent ingestion of water to balance up for its daily loss. As in normal individuals these daily losses for surgical patients are mainly for two processes (1) the water used for vaporization from the skin and lungs as part of the heat dissipating mechanism and (2), the water for kidney function. In the operation of these processes it is quite apparent that the heat dissipating mechanism has prior rights over kidney function for available water, the latter using for excretion what is left after the former has taken what it needs. On the surgical services of the University of Michigan Hospital, the staff is encouraged to think of the water requirements, and to order the glucose solution which provides the water on this basis: so many cubic centimeters for vaporization and so many more cubic centimeters for urine output. The figures to have in mind are arrived at as follows:

Vaporization from the skin and lungs for normal adults in comfortable environmental conditions varies from about 1000 to 1500 c.c. daily,[26] the larger figure being for the larger or more active individuals. These same figures have been found to be true for surgical patients who have no tax upon their heat dissipating mechanism. On the other hand, patients with fever or with hyperthyroidism, or when the environment is hot and humid, have the additional factor of sweating and more water is thus lost by varporization.[27] Wassel[28] investigated the vaporization loss in patients when the weather was particularly hot and humid and obtained figures from 2,068 to 5,034 c.c. daily. However, for any case complicated by some tax on the heat dissipating mechanism, the vaporization loss can be estimated at 2000 c.c. daily. More will be necessary with the extremes of fever and heat.

The amount of urine put out by the kidneys is a matter over which the physician has some control. Just what is a minimum permissible daily urine output and what is a satisfactory amount? Lashmet and Newburgh[29] have furnished information in this regard by making a comparative study of the excretion of water and solids by normal and abnormal kidneys. From their data Table III was composed and shows the amount of water needed to excrete 35 Gm. of waste material, which is about an average daily amount.

From Table III it can be seen that about 500 c.c. of urine is the very minimum daily amount, and is obtained only when normal kidneys are working at maximum concentrating ability. With volumes appreciably below this amount one may expect retention of waste materials, as shown by an increased blood nonprotein nitrogen. With diseased kidneys more water is needed, until with a concentrating ability down to a specific gravity of 1.014 to 1.010 approximately 1500 c.c. of urine is needed to do what the normal can accomplish with

* There are a few less sodium ions than chloride ions in Ringer's solution because of the presence of a small amount of KCl and $CaCl_2$ in that solution.

500 c.c. On the surgical services at the University Hospital it is considered desirable for the more seriously ill patients—those with sepsis, with severe biliary disease, etc., to put out 1500 c.c. of urine per day. For other patients 1000 c.c. is a good volume, since under the conditions of Table III, 1000 c.c. can be seen to cover all but the most seriously diseased kidneys.

TABLE III
MINIMUM AMOUNT OF WATER NEEDED BY KIDNEYS TO EXCRETE 35 GRAMS OF WASTE MATERIALS

Condition of Kidneys as Shown by Maximum Concentrating Ability	Sp. Gr. Urine	Water Needed, C.c.
Normal	1.032–1.029	473
Diseased*	1.028–1.025	595
	1.024–1.020	605
	1.019–1.015	850
	1.014–1.010	1439

* Chronic nephritis, pyelonephritis, renal tuberculosis, etc.

Other opinions have been given as to a satisfactory urine volume. Wangensteen[13] looks for an output of from 700 to 1000 c.c. per day. White, Sweet and Hurwitt[5] consider 800 to 1000 c.c. per day as best for neurosurgical patients. Graham,[30] in discussing the fluid requirements of patients needing surgical procedures for gastric or duodenal ulcer, asks for a urine output of at least 900 c.c. daily.

A summary of the discussion on the volume of water needed daily to maintain a normal water balance is shown in Table IV. The amounts are those generally accepted as suitable throughout the country. Here they are simply broken up so that one can know their component parts and deal with them as conditions demand. If sweating has been profuse, more fluid must be allowed for the vaporizing process or the urine output will be decreased. If there have been abnormal losses, such as by vomiting, saline solutions must be given following the previously discussed methods, or again the urine output will be low. One should always remember that a satisfactory water balance is shown by a satisfactory urine output, and conversely, a low urine output, particularly of high specific gravity—which means that the kidneys have good functional capacity and are working hard at the job of excreting waste materials in solution—signifies insufficient available water. It is a sign of progress that one now sees less of the old phrase "toxic suppression of the kidney function." There are many simpler reasons for no or little urine output and the commonest one is no or little available water.

TABLE IV
DAILY WATER REQUIREMENTS

	Cc.
Uncomplicated Case:	
For vaporization	1000–1500
For urine	1000
	2000–2500
Complicated Case (sepsis, hyperthyroidism, hot humid weather, etc.)	
For vaporization	2000
For urine	1000–1500
Abnormal losses (vomitus, etc.)	
	3000–3500

Glucose solutions are not only valuable because of their ready supply of available water but also because they provide food for energy requirements, and they protect the liver. Also, they prevent ketosis, and studies have shown that 50 Gm. per day is sufficient to accomplish this in the normal adult.[31] Five per cent glucose in distilled water is close to being isotonic. Winslow[32] found that an average of 98 per cent of the glucose was retained by a group of surgical patients given three liters daily at the rate of from 300 to 500 c.c. per hour. This rate easily permits the administration of from 2000 to 3500 c.c. in a few hours, and it should be given during the day, so that the night is left more comfortable for sleeping. Ten per cent glucose is hypertonic to blood and at the University Hospital it seems to be more frequently associated with phlebitis at the site of the injection than is the 5 per cent solution. However Winslow[32] found that 95 per cent of the

glucose in three liters of the 10 per cent solution given at the rate of 300 to 500 c.c. per hour, was retained daily by a group of surgical patients, who thus obtained 93 per cent more carbohydrate than if they had received an equal volume of the 5 per cent solution. The water of the 10 per cent solution appeared to be as readily available for all purposes as that of the 5 per cent solution. In patients needing more than just a moderate supply of carbohydrates, those with liver damage, with severe hyperthyroidism, with malnutrition and cachexia, the 10 per cent solution is particularly valuable. In its use it is important to remember that a slow rate of administration, about 150 to 200 c.c. per hour, provides continuous food and the least amount of glycosuria.

In conclusion one may well express appreciation for the availability and comparative safety of the different solutions on hand for the parenteral administration of water, glucose and salt. In the small as well as in the large hospitals this therapy is serving its purpose to carry the more seriously ill patients over periods of acute crises, and the best results are being obtained by thoughtful consideration of the needs of the individual patient.

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Water was never prescribed by ancient man *qua* water, but Plain Water, Well Water, Salt Water, Spring Water, and Cake Water, all vie in popularity with Water-from-the-Bird-Pond, Water-from-the Rain-of-the-Heavens, and most potent of all, Water-in-which-the-Phallus-has-been-Washed.

SEPTICEMIA, INCLUDING ACUTE INFECTIONS OF THE SCALP*

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THE limitations of this subject are not entirely clear: surgical septicemia is a very broad subject, the surgical and bacteriological principles of which I have discussed in a recent paper.[1] Acute infection of the scalp, while it is of common occurrence, fortunately rarely results in septicemia.

This paper, therefore, will endeavor to discuss briefly the concept of surgical septicemia and the development of various types of scalp infection. It will, then, present three cases which illustrate the common ground of these two somewhat diverse subjects.

By the term, septicemia, one generally means a diseased condition characterized by a sustained or intermittent fever in which bacteria are continuously or intermittently present in the blood stream and may be cultivated repeatedly therefrom by suitable means. This occurs both in medical and in surgical diseases, the latter being distinguished from the former by the fact that the organisms are of the necrotizing or pyogenic type which tend to destroy, and localize in, certain tissues of the body. The lesion does not tend to resolve spontaneously as in medical infections, but cure depends upon the process being evacuated or removed or isolated by suitable operative procedures. These organisms are, roughly, in the order of their frequency: (1) hemolytic streptococcus; (2) hemolytic *Staphylococcus aureus;* (3) nonhemolytic *Staphylococcus aureus;* (4) nonhemolytic streptococcus; (5) *Bacillus coli;* (6) anaerobic nonhemolytic streptococcus; (7) *Staphylococcus albus;* and (8) *Bacillus mucosus capsulatus.*[2] These organisms get into the physiologic interior of the body through some break in the primary defense of the body, namely, the outer surface covering of skin and mucous membrane or the inner surface covering of mucous membrane.

The staphylococci as a group may get in through an apparently intact skin because of their common habitat on its surface and in the pores draining the sweat and sebaceous glands and in the hair follicles. It is generally believed that they can live for some time in these regions and may multiply in the secretions from these glands and thus produce poisons which injure and destroy the underlying cells, thus breaking through into the deeper tissues.

The streptococci as a group are usually introduced at the time of an injury when the skin or mucous membrane is mechanically broken. Then, the organisms are carried into the deeper tissues as in accidental wounds, uterine instrumentation or dental extractions.

The colon bacillus generally gets in either through the alimentary or urinary tracts while *B. mucosus capsulatus* has a predilection for the alimentary and respiratory tracts.

It is extremely important for the doctor to attempt to cultivate organisms from the blood stream in any case of persistent or intermittent fever. An early knowledge of the causative organism may point to a hidden focus, for we know that certain organisms have a predilection for certain tissues, and in cases of sepsis are generally found in certain places in the body. Conversely, if the lesion is clinically apparent, experience leads one to predict with some degree of certainty which organism will be found in the blood, and its clinical

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behavior may be foreseen to some extent; for example: the hemolytic streptococcus is by far the most common organism in sepsis of otitic origin, infection of tendon sheaths, or in sepsis from a diffuse cellulitis, while the *Staphylococcus aureus* is more commonly associated with sepsis following carbuncles, suppurative parotitis, well-localized abscesses generally, and osteomyelitis. *Bacillus coli* is the common organism in sepsis from peritonitis and from bladder and kidney-pelvis infections. The nonhemolytic streptococcus is most often associated with the grave face and neck infections of dental origin. On the other hand, the hemolytic streptococci and *Staphylococcus aureus* share equally in the incidence of sepsis following severe infections of the kidney parenchyma. *Bacillus coli* and the nonhemolytic streptococci are equally involved and often found together in the liver and peritoneal abscesses, and either or both together are occasionally found in the blood in the later stages of these diseases. The hemolytic streptococcus and the hemolytic *Staphylococcus aureus* share equally in the incidence of vegetative endocarditis.

The frequency of positive blood cultures depends to a large extent on the frequency with which an attempt is made to grow organisms from the blood. Priceless time is often lost before the institution of proper treatment because of the failure to take blood cultures.

It is well known from experimental studies that when bacteria are introduced into the blood stream they are usually rapidly destroyed.[3] Whole blood in the test tube is not a favorable culture medium for most organisms but the circulating blood and the vascular system together are infinitely more efficient in destroying organisms which enter the blood stream. This clearing mechanism is performed by the cellular elements and by certain less easily defined, so-called humoral components in the blood.[4] The cellular elements carry on phagocytosis of bacteria and comprise the polymorphonuclear leucocytes, the macrophages of the blood, the endothelial cells, particularly of the lungs and liver, and the histiocytes of the reticulo-endothelial system. The humoral components include the various immune elements in the blood, natural or acquired, agglutinins, opsonins, bacteriolysins, antitoxins, leucines, plakins, and complement.

Under the most favorable conditions of artificial cultivation, bacteria multiply about once every half hour. Their multiplication within the blood stream must be very much slower than this if, indeed, it takes place at all. The blood makes one complete circuit of the body every minute, passing through the endothelial lined capillaries of the periphery, and the lungs, and possibly the liver also with each round. An organism has to run the gauntlet of phagocytic cells sixty or more times before it has time to multiply. It is extremely unlikely that there is any multiplication of bacteria in the blood stream until the blood has ceased to flow.

When a blood culture is taken from a peripheral vein at the elbow any organism which is recovered has passed the gauntlet of the lung capillaries and the capillaries of the periphery of the forearm or hand. The lungs filter out most of the embolic clots, and the endothelial cells pick up the individual organisms. If an attempt is made to determine the number of organisms per c.c. of the peripheral blood by means of agar pour plates, we find that even extremely sick patients seldom yield more than 100 colonies per c.c. of blood. This is a surprisingly small number if one considers that an ordinary twenty-four-hour broth culture of bacteria has anywhere from 1 to 5 billion organisms per c.c.

The actual number of bacteria which are primarily introduced into the body when the first break occurs in the protective surface, inside or out, is undoubtedly small, but they are frequently associated with some injury of tissue and the presence of foreign bodies. This association often enables the bacteria to survive and colo-

nize. They produce their specific poisons which damage or kill more tissue. Their toxins may attract or they may repel leucocytes. The white blood cells may phagocyte and destroy these organisms or be destroyed by them. Bacteria may be carried by the phagocytes directly into the lymph or blood currents and be filtered out in lymph glands or in the capillaries of the lungs or other organs.

The poisons also damage blood vessels and either cause the blood to clot within the lumen or liquefy their walls. Usually, the thrombi are first formed, then the wall is liquefied and the organisms invade the clot, thus producing a suppurative thrombophlebitis. The same process may go on in lymphatics and in arteries. In the wall of every abscess there are countless thrombosed blood vessels containing infected blood clots with sterile clot propagated peripherally in every one of these vessels. In most cases, this propagation of blood clot comes to a standstill when the abscess spontaneously breaks through the surface or is opened surgically. Not infrequently, however, the propagation of the sterile clot and the subsequent infection of the clot proceeds until it reaches a vessel of large size and a piece of clot either sterile or infected breaks off and is carried by the circulation until it reaches a capillary through which it cannot pass. If bacteria are present in such a clot they may be destroyed by the endothelial cells of the capillaries or they may form a new metastatic colony. This metastasis will be pulmonary, if the infective process is in a systemic vein, hepatic if it is in the portal system, or peripheral, if it is in a systemic artery or on the venous side of the pulmonary vascular system. When metastases occur, the whole process of distribution may be repeated on the venous side of the involved area.

As has been said above, bacteria introduced into the circulation from any primary focus or from any metastatic focus of infection may be destroyed in large numbers in the blood stream by the clearing mechanism, but if positive blood cultures are repeatedly obtained, we may be sure that the infected focus or foci are distributing organisms faster than the clearing mechanism can take care of them. If this goes on for several days, the whole body may be thoroughly seeded and metastatic abscesses may form anywhere and everywhere, enlarging the vicious circle and sooner or later causing the death of the patient.

In many cases when blood cultures are not taken frequently and in some cases when they are, the results are negative and yet the development of metastases makes it certain that organisms in small numbers at least, have been distributed through the circulating blood. This is particularly true in individuals under 20 years of age who develop an osteomyelitis. The reaction at the portal of entry of the organism may be so trivial as to have escaped attention and the metastatic focus in the bone becomes the distributing focus and is of major importance. Such cases have been explained on the theory that young persons have not developed sufficient resistance to these organisms to produce a reaction at the portal of entry, which would hold the bacteria at this site and not permit them to "invade" or be accidentally carried into the blood stream.[5]

The responsibility of the surgeon in cases of septicemia is obvious. As soon as a positive blood culture is revealed, it is the bounden duty of the surgeon to find the distributing focus or foci and to approach surgically all of the available foci; either to excise the whole lesion, or establish drainage, or isolate the process by proximal ligation of suppurative thrombosed veins. He is likewise responsible for using every other means at his disposal for destroying the organisms in the focus and in the circulation, for minimizing their further distribution and for building up the resistance of the patient to the infection. These points will be considered below.

Now, let us consider how these principles apply to acute infections of the scalp with which the forehead and back of the neck should be included. The former, though less hairy, has the same relationship to the skull as the hairy portion and is of variable height when there is any tendency to baldness. The latter is hairy like the integument over the skull and there is no distinct line between the neck and the portion of the scalp overlying the trapezius muscles.

The forehead, furthermore, is subjected to frequent trauma like the dome of the head. The back of the neck and lower part of the scalp proper are alike subjected to superficial irritation and to the development of furuncles and carbuncles, which not infrequently lead to septicemia.

The scalp is highly vascular and this is thought to be a factor in rendering this area less liable to the establishment of a serious infection than other areas similarly injured. Accidental incised or lacerated and contused wounds contaminated with street dirt are frequently sutured by physicians or surgeons without careful débridement or thorough cleansing and yet the development of a serious infection is rare. This fortunate outcome in the majority of cases, however, should in no wise justify the doctor in handling these cases in such a careless fashion, for the early and proper care of such wounds will usually result in healing without any evidence of infection whatsoever. When scalp wounds are associated with a compound fracture of the skull, unless a careful toilet of the wound is effected, the organisms frequently spread deeply and either invade the meninges or the blood stream or both.

Occasionally when brain operations are performed, the scalp wound becomes infected and this is of a much more serious consequence than wound infections elsewhere because the conditions are similar to those of a compound fracture of the skull.

The exposure of the lower part of the scalp and neck to rubbing from a collar often results in filling the pores with dirt and favors the development of a staphylococcus infection that may reach alarming proportions in a few days. If such lesions are subjected to squeezing or injudicious trauma by the surgeon's knife or if there is undue delay in instituting treatment, the organisms may be freely distributed into the blood stream by dispersion of infected blood clots in the periphery and a real septicemia may follow. This is shown in Case I.

Infections of the forehead and scalp not infrequently result from a direct spread upward from the face originating around the lips and nose, spreading superficially in or under the skin, as illustrated in Case II, or extending along the masseter and temporal muscles from infections in the upper jaw around the teeth.

Metastatic infective foci occasionally develop in the scalp in cases of septicemia. In most of these processes, an underlying bone focus should always be suspected, as Case III indicates.

ILLUSTRATIVE CASES

Case I. Seen in consultation in a suburban hospital. An Italian laborer, aged 21 had had a furuncle over the left mastoid region for several days. He asked a barber to nick it for him. Next day, he developed a severe pain in his left chest. That night, he had a chill and a temperature of 103°F. The next day, he consulted a physician. The doctor made a small incision over the mastoid region, but because of an increase of his symptoms, next day the patient was admitted to the hospital.

Physical signs confirmed by an *x*-ray film of the chest on admission, revealed bronchopneumonia in the left lower lobe and two days later, it involved both lower lobes. A blood culture taken on the day after admission yielded hemolytic *Staphylococcus aureus*. Sulfanilamide was administered on admission, but on the second day was replaced by sulfapyridine. Hot boric acid packs were applied to the carbuncle which continued to advance. On the day the positive blood culture was reported an initial dose of staphylococcus bacteriophage was given and there seemed to be an encouraging fall in temperature, but for two days on the advice of the attending

physician no more phage was given. Instead 100,000 units of staphylococcus antitoxin were given on the first day and 25,000 units on the next. During the afternoon and evening of this day, his temperature steadily mounted.

I was asked to see the patient on the evening of the next day, which was the sixth after admission to the hospital. The man was desperately sick. The carbuncle covered most of the left side of the scalp with numerous small openings giving inadequate drainage. The left eardrum was bulging. Incision released pus from the middle ear. A film of the mastoid showed no involvement. I recommended the readministration of bacteriophage intravenously, the irrigation of the involved area with phage and wide incision if no improvement occurred in twelve hours. This operation was performed next day, but after twenty-four hours of slight improvement, the temperature steadily rose until death on the tenth day after admission. Transfusions and antitoxin were continued as well as sulfapyridine, but naught availed. Post-mortem examination revealed, besides the extensive carbuncle of the scalp, a general bronchopneumonia in both lungs with both pleural spaces obliterated by extensive fresh fibrinous adhesions. Heart, liver, kidneys and mastoid were not involved.

This case illustrates the rapid development of septicemia and bronchopneumonia following trauma to a furuncle of the scalp. It is possible that from the time the patient first applied to a doctor, no treatment would have saved him because of the extensive seeding of his lungs, but his chances of recovery would have been immeasurably increased if there had been an earlier exposure of the carbuncle permitting the better local application of bacteriophage and if there had been no interruption to the intravenous administration of the phage in large doses.

Case II. Seen in consultation in a suburban hospital. A well developed and well nourished lad of 17 developed a boil on his left forearm, which was quickly followed by another on the left side of his face back of the outer angle of the eye and a third on his nose. The first two remained localized, but the third became a carbuncle and spread rapidly over to the cheeks involving both eyelids, up the nose to the forehead and gradually involved the whole forehead, including the anterior hairy portion of the scalp. Temperature daily reached 104 to 105 degrees with daily chills. Blood culture revealed hemolytic *Staphylococcus aureus*. Cold applications were applied without halting the progress of the infection. On the eighth day of his illness with the patient rapidly becoming worse and the outlook extremely bad, I was called to see him and recommended the rapid administration of increasing doses of doubly potent staphylococcus bacteriophage intravenously and the local injection of phage with a hypodermic needle around the periphery of the lesion in the forehead and scalp and irrigation with phage through a blunt needle in all of the openings on the nose and eyelids. Definite improvement was evident in twenty-four hours and this increased steadily. Blood cultures taken daily became negative after five days. Swelling of the forehead, nose and cheeks subsided rapidly and that of the eyelids more slowly. He was able to leave the hospital on the tenth day after the first administration of the bacteriophage.

This case illustrates the favorable response to potent bacteriophage when administered early and in large doses both intravenously and locally in a situation in which the outcome is usually unfavorable because of the early development of a cavernous sinus thrombosis.

Case III. Treated in the Presbyterian Hospital, New York City. A well developed man of 46 had a huge carbuncle measuring 10 × 15 cm., involving almost the entire back of the neck and lower scalp. It was of five days' duration and there had been repeated chills and high fever. In the center of the carbuncle there were two openings about ½ and 1 cm. in diameter with a bridge of skin separating them. The lesion was more sharply defined on the right margin than on the left where it seemed to be spreading rapidly. The blood culture was negative. The carbuncle yielded pure hemolytic *Staphylococcus aureus*.

The lesion was treated with doubly potent staphylococcus bacteriophage. The central portion could be irrigated with a No. 18 gauge blunt needle on a syringe through the central opening. Phage was also injected around the

periphery on the left with a No. 28 gauge sharp needle. Temperature gradually fell and the lesion became localized. The center rapidly liquefied and on the tenth day a huge mass of slough separated and was removed through the central opening, which had progressively enlarged. The patient left the hospital on the nineteenth day and the wound was entirely healed on the twenty-third day.

A week later the patient was readmitted with a soft painful swelling 5×2 cm. in diameter in the scalp high up on the left temporal region. On the day before admission, he had suffered a severe chill. An *x*-ray film revealed no bony changes. An incision was made over the swelling with the expectation of finding pus. This was carried down through an edematous temporal muscle to the bone but no pus was found. Blood culture was negative but a culture of the edema fluid yielded hemolytic *Staphylococcus aureus*. The wound was irrigated and lightly packed with gauze soaked with bacteriophage. The wound contracted steadily and the patient left the hospital on the fifth day, but the wound did not completely heal—a sinus persisting. Four weeks later another film was taken of the skull and a sequestrum of the outer table was revealed. This was easily removed without disturbing the rest of the bone. When last seen in clinic, the wound was healed except for a small granulating surface. Subsequently another small abscess developed in the left occipital region which was superficial and responded to incision with local instillation of bacteriophage.

This case illustrates a metastatic focus in the skull following a large carbuncle of the neck. This was almost certainly blood-borne even though repeated blood cultures were negative. The subsequent abscess in the occipital region may have been in a smoldering lymph gland draining either the metastasis or the primary lesion.

PRINCIPLES OF TREATMENT

As we have said above, and repeat for emphasis here, whenever the surgeon is faced with a problem of septicemia, it is his bounden duty to find the distributing focus and either remove it, drain it, or isolate it by ligating the proximal vein. He must, likewise, make every effort to destroy the organisms in the focus and in the blood stream so as to minimize the further distribution of the bacteria. In particular, in acute infections of the scalp much can be done by prophylaxis. Recent accidental wounds should be thoroughly debrided, cleansed and either carefully sutured if fresh, or left open if old, and a culture of the debrided tissue should be made to reveal the organisms with which one has to deal. Furuncles of the scalp or face or neck should be treated conservatively with iodine if superficial or with potent bacteriophage through a blunt hypodermic needle if deep, great care being taken to minimize trauma. Active surgical treatment when an acute infection has developed and has resulted in a septicemia, should aim at removing as much of the distributing focus as possible. In very sick patients with carbuncles, particularly in diabetics, excision is often better than more conservative treatment. If the organism is a hemolytic streptococcus, sulfanilamide or sulfapyridine should be given in adequate doses to maintain a blood concentration of 5 to 10 mg. per cent with precautions taken to note any early evidence of toxicity from these drugs. The wound should then be treated daily with a creamy suspension of medicinal grade zinc peroxide (Z.P.O.) in sterile distilled water, care being taken to obtain contact with every part of the infected surface and the dressing sealed to prevent evaporation.

If the organism is a staphylococcus, the organism must be tested for its susceptibility to doubly potent bacteriophage[6] and if it is susceptible, this should be given intravenously in increasing doses—at first every hour starting with 0.25 c.c. diluted ten times in saline and increasing as follows: 0.5 c.c., 1 c.c., 2 c.c., 3 c.c. and 4 c.c. If a reaction occurs with any of these doses, the administration should be stopped for eight hours and then continued every eight hours in gradually increasing doses up to 10 c.c. every eight hours. If no reaction occurs with the initial doses, the

amount may be increased rapidly up to 50 c.c. every eight hours until two successive blood cultures are negative and the temperature is normal. Phage should also be administered freely locally so as to reach every part of the distributing focus if no surgery has been done or every part of the residual infection if surgery has been done. Sulfapyridine should also be tried in staphylococcus infections. Sometimes it seems to be effective and at other times not at all. It does not interfere with the action of bacteriophage.

Potent bacteriophage should be used in B. coli septicemia in the same manner as in staphylococcus infections, but it is of no vaue at present in streptococcus infections.

By "doubly potent" bacteriophage is meant phage which will not only clear (lyse) a broth culture of the organism but one which will prevent a transplant from this cleared culture from growing any colonies on a blood agar plate.[6]

Serotherapy has been disappointing in my experience, but should be tried in staphylococcus septicemia. At present, antitoxins are contained in available sera, but no antibacterial antibodies, although Lyons[7] is hopeful of being able to produce such sera by the use of vaccines made from young encapsulated organisms. Occasionally, with the available commercial serum given in huge doses up to 250,000 units in conjunction with sulfapyridine, favorable results have recently been reported.[8] Cadham[9] has published some striking figures of recovery in staphylococcus septicemia following the use of "immune" rabbit serum together with normal human serum. Blood transfusions are of value only if there is an indication of loss of red blood cells. This opinion is concurred in by a number of unbiased observers.[2,10,11] We have no evidence that any immune substances are carried over except occasionally in streptococcus infections when the donor's blood is found to have a high opsonic index for the infecting organism.[12]

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THE TREATMENT OF TRAUMATIC WOUNDS*

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"THE proper treatment of wounds is to be regarded as the most important requirement for the surgeon" (Billroth). Although this statement was made nearly seventy-five years ago, we believe it is equally applicable in all surgery of today.

We are assuming that those who read this paper have an understanding of (1) the importance of blood supply in the healing of wounds; (2) the dangers of necrosis, débris and blood clots in a wound; (3) the difference between a contaminated and infected wound; (4) what healthy, living tissues can do to combat infection; (5) the value of immobilization in the healing of wounds; (6) the effect the state of health of the wounded person has upon the healing of his wound; (7) the origin of the food which the cells must have in order to grow and heal a wound; (8) the effect of heat and cold upon the proliferating cells; (9) the damaging effects of germicides upon delicate living cells; (10) the damaging effects of tension in a wound; (11) the rationale of moist dressings for a wound; (12) the methods of growing tissue in vitro; (13) the effects of vitamins and various chemical salts upon cell division etc. (see Reid, M. R. *New England J. Med.*, October 22, 1936 and Christopher's *Textbook of Surgery*, 2nd Edition).

A great deal has been written in recent years about wounds and wound healing. One finds it a topic of discussion at almost every meeting of a surgical society and a subject in nearly every issue of a surgical journal. There is an explanation for its deserved popularity. Doctors who encounter considerable difficulty in the prompt healing of their elective or accidental wounds provide a receptive and appreciative market for such information. Others who have been able to reduce their difficulties to a less alarming degree are only too glad to offer their own remedies.

If one will carefully follow the reports that come from the widespread medical centers of the country, he will be a little disappointed to find a great similarity in all of them. No panacea or new technical trick has been offered. However, on second thought, one should be encouraged rather than discouraged. By comparison one will observe that the underlying trend of uniformity in the articles on the treatment of accidental wounds is due to the widespread approval and acceptance of sound fundamental principles of surgical technique and the incorporation of these ideas in the articles. This is mentioned not for the purpose of criticism, but of praise. When identical thoughts come from so many sources, it means that we must be on the right road. As long as these fundamental principles can be held as standard before the students of surgery then it must be admitted that its institutions are coöperating to train men of high-grade, uniform caliber. It is a great step in advance and its future looks bright.

In spite of all the ideals advanced in a proper surgical technique, it is impossible to escape the personal factor in operators themselves. Every surgeon in his course of work has had the experience of assisting another who knows good principles of surgery, but who does not always apply them. Such an individual will call attention to and do nothing about a poorly shaved

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skin, neglected skin cleansing, small area of skin preparation, tags of tissue strangulated by ligatures, clamps applied with large bites of tissue, tight sutures (Fig. 1), breaks in technique, suturing under tension, closure of a wound in which active bleeding is still in progress, use of heavy suture material when a proper grade could be had for the asking, etc.

Some surgeons will be guilty of these faulty practices only on occasion, while others will let them become a habit. Every surgeon will recall times when he has taken more liberties with his wounds than was his usual custom. And every one will recall instances when he has regretted having taken such liberties. The variables among patients and disease are too great for a doctor to be adding his own technical flexibilities.

It is hardly necessary to call attention to the great physical and economic losses which constantly occur as a result of neglect or improper management of traumatic wounds. Even though one should employ the important fundamentals in handling tissues as mentioned in the preceding discussion, there still remain many pitfalls between the reception of a contaminated wound and its release with uncomplicated healing. Relatively clean wounds usually will heal, even though these fundamental principles of wound healing are not rigidly observed and it is this fact which tends to make many of us careless. Troubles usually begin when contaminated wounds fall into the hands of those who have become somewhat lax in the handling of "clean" wounds. The real test of a surgeon's skill is his ability to treat dirty wounds in such a way that they will heal by first intention. It requires all of the gentleness, thoroughness and patience that one can call forth; but the results are well worth the effort.

It is to be understood that we are for the present limiting "traumatic wounds" to "open traumatic wounds." Our terms must be quite general because they are to include all types from the simplest laceration to the most severe compound fracture.

If every facility is not at hand to give satisfactory final treatment to the wound, nothing but first aid should be rendered and the patient prepared for transportation to a hospital. Entirely too many foreign bodies, open joint spaces, cut tendons and nerves are being covered by skin suturing in wayside stations. A patient is none the wiser until the infection refuses to subside or function fails to return. The best result of delayed tendon or nerve suture is seldom so good as that obtained by proper care immediately after injury.

There are many ways of controlling hemorrhage in fresh traumatic wounds and some of them should be used with considerable discretion. The blind application of hemostats in a bleeding, unanesthetized wound is not only cruel but frequently harmful. Nerves, tendons, muscles and even intact vessels are often crushed. Clamps dangling from the wound add to the shock, and contaminating materials are mixed with the tissues. For similar reasons the packing of wounds with gauze should be discouraged, although there are times when one must resort to it.

Tourniquets should not be applied in a routine manner. Most wounds will stop bleeding with elevation and the application of large pressure dressings and these measures should be given the first trial. Sometimes tourniquets do not cut off arterial pulsations and merely bring about congestion to promote venous bleeding. They are useful on mangled extremities to check bleeding and to stop absorption of toxins from damaged tissues. In these cases tourniquets are best placed as close to the wound as possible, so that they do not have to be removed before amputation and are not producing useless and harmful ischemia in the part of the extremity that is going to be saved.

Severe cuts of the extremities and all fractures of long bones should be splinted. No antiseptic is to be placed in a wound and no wound irrigation employed if the

patient can be moved to a hospital within six hours. Dirt in a wound during this time will do little harm if the debridement is adequate and not too long delayed. Dirt particles removed from a wound before the operator sees it may give him the wrong idea about the degree of contamination and thus result in short cut or inadequate measures. Do not attempt to set a compound fracture or even reduce the exposed end of a fragment protruding through a wound. It serves as a plug to protect deeper structures from soiling. Its reduction before operation will add hours to the procedure and may alter the result.

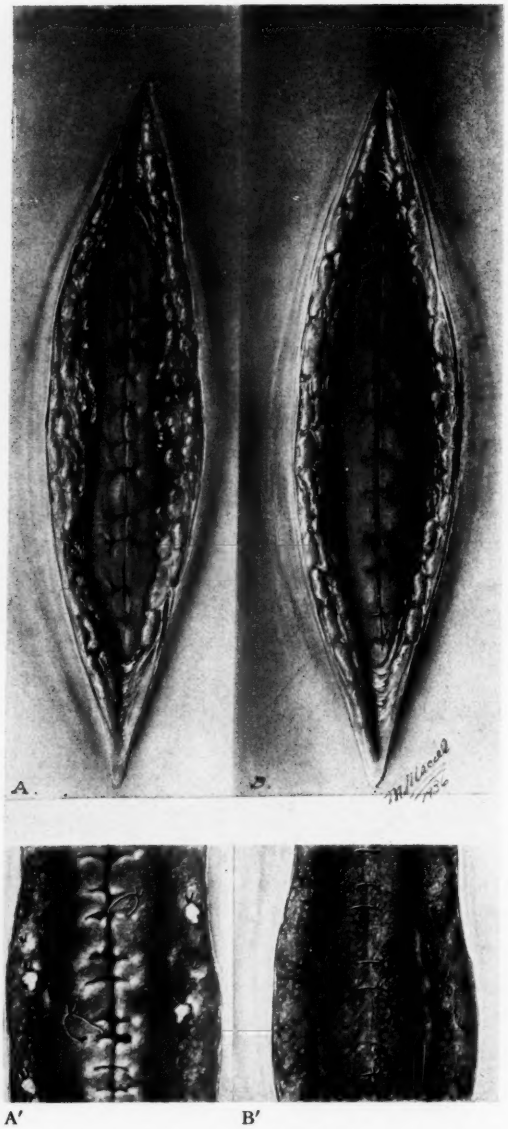

FIG. 1. A and B, rectus incisions made under identical conditions on a dog. In A the fascial sutures were tightly drawn and large tags of tissue were strangulated by ligatures. In B the incision was handled very carefully so that the tissues were not torn. Bleeding was controlled without ligatures and the fascial sutures were made just tight enough to approximate the edges.

A′ and B′, the same wounds opened for inspection five days later. Neither one was infected, but in A′ the tight sutures had produced necrosis and had cut through the fascia. B′ showed smooth granulation tissue over its entire surface, but A′ still retained tags of slough distal to the ligatures. B′ has far greater resistance to infection than A′.

The operator must use his own judgment as to the type of anesthesia. Major wounds, such as those involving nerves, tendons and bones, are usually best repaired under a general anesthetic. Superficial minor wounds are easily handled under local. All debridements requiring considerable dissection should be done under tourniquet whenever possible. A blood pressure cuff is highly satisfactory because it can be released at varying intervals during long operations without disturbing the draperies.

Never start a major debridement without intravenous and transfusion facilities; and never attempt one without adequate and trained assistants. It is not the time to teach a novice who may recognize a gross contamination in a clean set-up but who can't appreciate the difference between clean and dirty areas of a wound undergoing debridement.

If pain is not a factor, the part is prepared before the anesthetic is started. A sterile gauze is placed over the wound, the entire extremity is then washed with soap and water and shaved up to but away from the wound edges. If the injury is near the hand or foot, the part is scrubbed and the nails given the same meticulous care that the operator would give his own hands. The water is removed with alcohol and the alcohol removed with ether. This preparation should be done by the surgeon who has already scrubbed and is in sterile gown and gloves. The tourniquet is then pumped up and the unsterile gauze removed. Any overflow of blood or serum is washed from the skin surface. The surgeon then removes

gown and gloves and puts on sterile gloves for draping. Any good skin antiseptic is used freely and over a wide area but never allowed to enter the wound. Plenty of room is given in draping.

Debridements under local anesthesia are difficult because a tourniquet becomes painful to the patient. The purpose of the tourniquet is to save blood and to prevent unnecessary clamping of many bleeding points, which reduces the amount of ligature material in a wound and the time spent to put it there. The tourniquet maintains a clear dry field for the dissection and enables one to avoid soiling of freshly cleansed areas by the overflow of tissue juices and blood, or by frequent sponging of the field with gauze which will so easily touch both clean and dirty areas at the same time and also add unnecessary trauma.

The plan for the debridement at this stage is to use two sets of instruments; one for the actual debridement and one for the necessary surgical repair and closure.

A dry sponge is tucked into the wound. Clamps are applied about the skin edges for traction. An elliptical incision is made through normal skin about ¼ inch from the edge in large wounds. This is carefully developed into the fat but not through it. As the incision approaches the cavity, blood stains are observed in the tissues and its direction is changed. The clean skin flap is undermined as the edge is held up by small retractors. The undermining continues until the subcutaneous fat joins the muscle fascia. If there is doubt as to where this occurs, the clean wound is protected with moist flat gauze, the field protected with towels, the fluff removed from the dirty wound with a clamp and the cavity inspected. Another dry gauze is replaced and the clamp is kept in a separate basin for similar future use. In this manner the entire wound follows the muscle fascia and torn muscle bellies. Long fibers are split with a knife and incisions crossing the fibers are best made with small scissors. Areolar tissue can be followed along periosteum, vessels, tendons and nerves. Always protect the field and clean wound with towels and moist gauze, so that in case of contamination the protection can be changed or removed, rather than covered over and allowed to remain as another source of unrecognized contamination.

Often the dirty wound can be lifted out without a serious break in technique. Severed tendons and compound fractures give the most trouble. In the latter case the dirty cavity is entered when the broken fragment is encountered. However, there need not be any contamination if one is careful to keep the clean surfaces covered. The soiled specimen is clipped free and discarded. The wound is next lengthened in either longitudinal direction until the end of either fragment can be brought out for further debridement. Soiled periosteum stripped from the bone must be sacrificed. It is at this stage when the delayed washing of a wound is most appreciated. Dirt particles are now visible and there is no guesswork in their removal. With an osteotome or thin chisel, a shaving of cortex is started from the clean portion and carried to the end of the soiled fragment. It is picked off with a clamp and discarded. The entire area of bone denuded of periosteum is cleanly shaved in this manner. The tip of the fragment is cut off with the same instrument or perhaps a saw or bone cutter. It is not advisable to use a rongeur for any part of the work. Its biting edges always pass through soiled surfaces, besides tending to leave partially detached pieces of bone.

When debridement of the fragment is completed, it is covered with gauze and returned to the wound. The end of the other fragment is lifted out and similarly treated. After this is done the extreme depths of the wound are systematically given debridement and the cavity is ready for irrigation. Large quantities of warm, but not hot, saline are used. If the fluid is removed by aspiration, one should never use a tube which has been in contact with intra-abdominal or thoracic pus

because boiling water under ordinary conditions will not kill spores. The wound is gently rubbed with a gloved finger to detach pieces of loose tissue and blood clots.

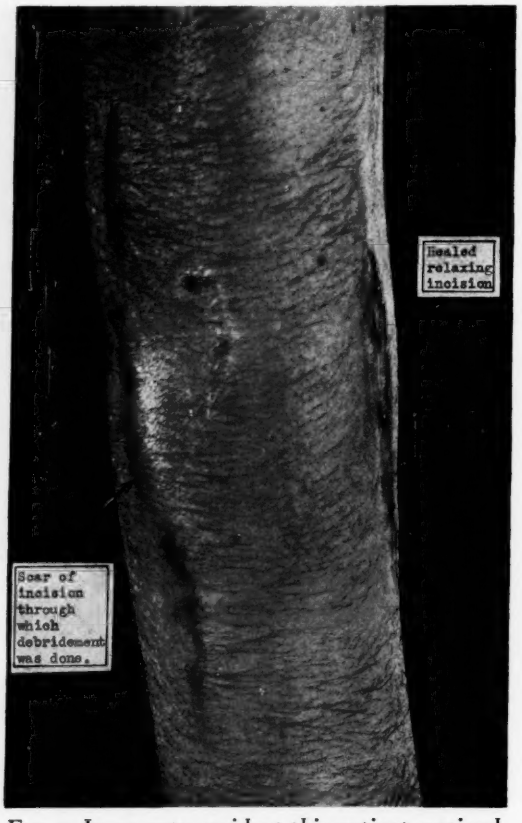

Fig. 2. In an auto accident this patient received, among other injuries, fractures of both bones of the right forearm with the ulnar fracture exposed through a 4 inch laceration. The wound was filled with gravel. There had been no displacement of the fragments so that debridement was essentially that of a soft tissue wound. The swelling caused by the fractures prevented closure of the wound, and a single relaxing incision had to be made. The strip of tissue between incisions was dissected free from the fascia of the muscles and allowed to shift to the ulnar side for suturing. The remaining defect was packed with vaseline gauze and permitted to heal by second intention. This photograph was made three months after the injury. The arm has recovered its full use and the disfiguring scars are ready for excision and accurate closure.

Relaxing incisions must be kept far enough away from the main wound to insure adequate blood supply for the strip of skin to be shifted. Sometimes there is sufficient relaxation without complete detachment of the strip from the underlying muscles. These incisions should be long enough to permit loose closure of the main wound through its length.

During the operation and before removing the tourniquet, any known open vessels are ligated with fine silk. The cavity is again irrigated after the tourniquet has been released. Inspection is then made for ischemic pieces of tissue which are to be trimmed away. Hemostasis is made secure, but this does not imply the use of unnecessary ligatures. At this stage a few moments of waiting and the use of gentle moist gauze pressure will effectively stop many bleeding points.

No mechanical fixation of bone fragments in the wound is employed. Tendons and nerves are sutured with silk. The wound is closed with interrupted sutures of silk in the fascia and skin. If the closure is under tension, and it usually is in fracture cases, counter-incisions are made on either side to give relaxation. (Fig. 2.) These defects may be skin grafted or packed with vaseline gauze and allowed to heal by second intention. Viability of skin over the fracture site depends on a closure without tension; the conversion of a compound fracture to a simple one depends on the skin remaining viable and intact. A moist gauze dressing is applied. The fragments are immobilized by skeletal fixation with pins or by cast alone, depending on the type of fracture; but they must be perfectly immobilized. The patient is given the usual prophylactic dose of tetanus and gas bacillus antisera. The dressing is not disturbed for a week or ten days unless there is an unexplained rise in temperature or abnormal pain.

Let us call attention to the word "debridement" which has been defined as the "excision of a wound." The term has degenerated in its application. Almost any form of wound cleansing has been called debridement and wrongly so. Most doctors know what it means and start such operations with every intention of being thorough. The skin and fat receive fair treatment. Then many of us will begin washing the wounds to take away every bit of the evidence of deep seated dirt. The rest of the procedure will be devoted to aimless picking and clipping of tags of muscle and

fascia over its surface. To be sure, the wound will look clean. One can wash the hematoma and extravasated blood from the muscles of a dressed rabbit which has been shot, but it will still be riddled with bird shot, hair and material from the intestinal tract. The operation doesn't terminate because the work has been systematically completed, but because patience has been exhausted and one doesn't see anything more that can be done. Such a method will work in many cases of superficial, simple incised or lacerated wounds. In fact there is a great deal in its favor for wounds of the face where the blood supply is good, tissues show great resistance to infection and extensive debridements often lead to serious distortions. Elsewhere the method is not reliable and should be discouraged.

T. S., age 24, was admitted to the hospital February 5, 1937 with a compound fracture of the left leg at its middle third. It had resulted from a pile of bricks falling on the extremity.

General examination was not remarkable. The leg presented a laceration 4 inches long at the site of the fracture. There was gross soiling of the wound. No history or evidence of bone protrusion could be obtained although the fractured ends were visible in the wound. Four hours after the accident the patient was operated on under general anesthesia. Debridement was carried out as outlined above. Upon inspecting the bone, gross dirt was found embedded in the periosteum at the point of fracture. It was removed according to the method described. Silk was used throughout. The closure was facilitated by accessory incisions which were later dressed with vaseline gauze. The leg was placed in a padded cast and supported on a knee flexion splint. Gas and tetanus bacilli antisera were given and the patient returned to the ward in good condition.

The temperature curve showed spiking to 101 degrees in the first three postoperative days. It then dropped to normal for one day and spiked again on the fifth, sixth and seventh days. At this time there was evidence of a moderately severe serum rash. The fever and elevated pulse were not accompanied by any increase in respirations. The fever promptly subsided with the rash. All sutures were removed at the end of two weeks when the first dressing was made. The relaxing incisions were redressed and found to be nearly closed. The patient was discharged to the fracture clinic on February 23 to be treated as if he had a simple fracture.

A time limit of six hours has been placed as an arbitrary dead line for relatively safe debridement of accidental wounds. After six hours the bacteria which formerly were responsible for a state of wound contamination have begun to multiply and to invade the surrounding tissues. Some are of the opinion that it marks the time when contaminating organisms can no longer be washed from the wound surfaces because of their spread to deeper layers by active invasion. This attitude is somewhat misleading since it implies that a contaminated wound can be made sterile by washing. Some of the organisms are removed, it is true, because positive cultures can be made from the washings. However, as a matter of fact many bacteria are probably forced deeper into the tissues. If one will examine a wound after copious irrigation, one will see that the areolar tissue planes and loose structures are bulging with fluid just as though they had been infiltrated with a local anesthetic. The greatest advantage to be derived from wound irrigation is the removal of blood clots, fat droplets and shreds of devitalized tissue, all of which act as foreign bodies in wounds and help to provoke infection when contamination exists.

To cite an example which may aid in clarifying our attitude toward wound irrigation we mention a common story which arises in connection with appendectomy wounds for ruptured appendices. For several years we have closed the peritoneum without drainage in our cases of perforated appendices with peritonitis without localized abscess. The wounds were then thoroughly irrigated with liters of saline and closed. Here should be an ideal case for rendering a wound sterile by washing. The wounds had been made by sharp instruments and every condition provided for primary healing, including a negligible time factor, except for the fact

that pus, carrying virulent organisms, had flowed over its surfaces. Wound abscesses occurred so regularly that it was but a short time until a small rubber drain down to the peritoneum was being left in each case.

A different story is found in laparotomy wounds which can be protected fairly well from procedures of known contamination. Soiling undoubtedly occurs when an open anastomosis is done for ileotransverse colostomy. The abdominal wound is always well protected with heavy laparotomy pads. Observing the same technique in closure, including copious irrigation after peritoneal closure, we have found wound abscess to be the exception rather than the rule.

Tissue susceptibility and type of organism play a part, but the degree of contamination rules the wound. Once more let it be said that this cannot be determined by inspection and one is hopelessly lost by early irrigation of a wound if he plans to do a real debridement. The last case cited brings out the reason why a large dirty wound can be successfully excised and made to heal without infection. The secret is the keeping of a constant vigilance for the protection of freshly excised surfaces by the application of moist flat gauze.

The six hour rule against debridement is not a rigid one and yet the contraindications for operation after that time are not very clear. If smears of tissue juice taken eight or nine hours after injury begin to show large numbers of bacteria, debridement should not be done in case of compound fracture or cases requiring nerve or tendon suture. Debridement is designed to prevent infection. It necessitates the sacrifice of portions of bone, periosteum, nerve, tendon, muscle, fat and skin in order that further loss of tissue, function, time and money may be avoided. When it is certain that infection can only be lessened, then the usual type of wound cleansing may be employed. By the "usual type" we mean the trimming away of skin edges, washing of the wound and removal of tags of devitalized tissue. After such a wound has healed by secondary intention an elective procedure may be planned for delayed repair of tendons and nerves with silk. Unnecessary loss of portions of these structures by unwise debridement, additional destruction by suppuration about the sutures, coupled with repeated probings along draining sinuses will be prevented.

Debridement has a most important part to play in the treatment of animal and human bites. So far, it has not been widely used, the general trend still being the swabbing and probing of nitric acid or phenol into wounds. Acids are very destructive to tissues and are extremely unreliable in combating contamination. The effectiveness of cauterization cannot be judged by the low incidence of rabies among patients because there is a similarly low incidence of rabies among dogs under observation. Anyone bitten by a truly mad dog should and usually does receive anti-rabic treatment. One cannot definitely say what the effect of debridement would be against the filtrable virus of rabies. If its behavior can be predicted from the observation of other well known viruses, there is no reason why contact with a rabid animal would not permit self inoculation through skin abrasions and mucous membrane surfaces. Excision of the wound can be relied upon at least to prevent infection by secondary organisms.

Human bite infections offer a different problem. The number of tendons, fingers and hands which are lost each year from these accidents must be appalling. The injury is nearly always received in a fight at which time the hand is cut when it strikes the teeth. Usually the injury is over a knuckle and the tendon is exposed or severed. The common methods of treatment are cauterization with acids, wound irrigation and suture. Prophylactic wet dressings are often employed. They are about equally ineffective when the offending tooth resides in an unhygienic mouth. By the second or third day, cellulitis begins and the purulent discharge has the characteristic odor of a lung

abscess or the breath of one who has a mouthful of carious teeth. Its course is familiar to all in that the inflammation will involve the full length of the tendon, neighboring tendons, adjacent joint spaces and often fascial spaces of the hand if drainage is inadequate. The acute inflammation is quickly followed by gangrene which probably accounts for its malignant invasion of adjacent structures.

The initial injury is usually small and the patient is frequently responsible for its early neglect beyond a reasonable hour for preventive surgery. If one is favored by an early call, he has an opportunity for preventing one of the most destructive infections by doing one of the simplest of debridements if he will only take the time to do it.

Thus far we have confined our remarks to the debridement of wounds in general; and, particularly, those wounds whose skin edges can be approximated. It may frequently happen that it is impossible to close a wound by suture following its complete debribement and cleansing. This may occur as a result of loss of skin in the accident or the necessity of cutting away skin which has been devitalized. In such cases much loss of time and trouble may be avoided by the immediate application of a skin graft. As has been stressed especially by Koch and Mason, this is particularly true of wounds of the hands and feet where there is little excess of skin which may be used for closing the wound. As an example of the use of immediate skin grafting in such instances we cite the following case.

R. M., age 47, entered the hospital February 12, 1938 following an injury of the right hand sustained while cranking an automobile. The engine had "kicked," causing the end of the crank to tear through the dorsal surface of the web between the thumb and index finger. The skin and subcutaneous fat were missing. The extensor pollicis longus tendon was exposed, the adductor pollicis muscle was almost completely mangled and there was a compound fracture of the first metacarpal bone at its middle third.

Three hours after the accident, debridement was begun under local anesthesia with the realization that skin grafting would have to be done in order to close the defect. However, a bridge of extensor pollicis longus tendon across the wound had not been anticipated. It would have been better to have covered the wound with a flap of skin and subcutaneous fat from the abdominal wall. However, the patient could not stay in the hospital and to simplify his care a split graft was removed from the thigh to cover the defect. Six weeks later he returned to his job as pressman in a print shop.

Fig. 3. Primary skin graft to cover a tendon exposed through loss of overlying tissues by injury. See report of case.

The photograph, Figure 3, shows a very superficial position of the tendon. Although the graft is adherent to it, there is enough freedom in movement in other tissues beneath the graft to give the thumb a full range of function. It is doubtful whether this tendon would have survived any delayed form of grafting. The patient still refuses further correction.

THE PREVENTION AND TREATMENT OF TETANUS*

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THE American medical profession has been amazingly slow to realize that the prevention of tetanus can be effectively accomplished by active immunization against the disease. The great majority of practitioners wait until a suspicious injury occurs, and then give a prophylactic injection of antitoxin. Their failure permanently to protect their patients from tetanus by the use of toxoid comes either from ignorance of its existence, or from misgivings as to its efficacy. The purpose of this paper is twofold: first, to present briefly some of the facts that are known about tetanus toxoid, and second, to consider the treatment of tetanus in the light of recent experimental work.

Before passing on to these two subjects a few comments on the prophylactic use of antitoxin may be in order. It is known that following the administration of 1500 units of tetanus antitoxin the recipient's serum has from 0.1 to 0.25 of a unit of antitoxin per c.c. This titer is maintained for only a few days (four to eleven); consequently, in extensive injuries, or whenever an operative procedure is attempted, a week or longer after the injury, it is advisable to repeat the dose of antitoxin. Experience has shown that in those few instances in which the prophylactic injection has failed to protect the patient from developing the disease, the injection does, however, ameliorate the severity of the symptoms and lowers the mortality. A common error in the use of antitoxin for preventive purposes is to grade the dosage in proportion to the patient's age. Obviously, the wound of an infant may elaborate as much tetanus toxin as the wound of an adult. An antitoxin is given to neutralize this toxin, and consequently the patient's age has no bearing on the quantity needed.

To give or not to give tetanus antitoxin prophylactically is one of the most perplexing questions that haunts the practice of every conscientious doctor. There are no tests or laboratory aids to help solve this problem. Furthermore, severe untoward effects of repeated injection of foreign proteins are increasingly frequent. In fact, serum sickness of a severe grade can occur after an injection of 1500 units of antitoxin, even when the ophthalmologic and skin tests are negative. Because of the hazards incident to inoculations of antitoxin and because it is impossible to give a prophylactic injection after very slight injury, it is extremely desirable that a substitute be found for tetanus antitoxin. Such a substance has been found in toxoid.

The first work with tetanus toxoid was done by Ramon[1] of the Pasteur Institute nine years ago. The interest of the French immunologists in the substance has been sustained. Their experience with it has grown rapidly, for not only has every French soldier been given tetanus toxoid but also all of the horses of the French army. It is important to note that in the past from forty to sixty horses in this group died every year from lockjaw. Last year, however, not a single such death occurred in the 60,000 horses that had been actively immunized with toxoid. In this country there has been a reluctance to rely upon toxoid, largely because of the early reports which seemed to indicate that a small percentage of the population are refractory to it. The latest workers, using an improved technique, fail to find any individuals who do not respond satisfac-

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torily after a properly given course of injections. A large amount of experimental work has been and is being done with toxoid. Sufficient data have been accumulated to justify its widespread use. A brief summary of our present knowledge follows:

Dosage. The purified alum precipitate is more efficacious than plain toxoid. An effective immunity can be obtained after three subcutaneous injections of 1.0 c.c. of toxoid, given at six to twelve week intervals. The first injection causes no detectable production of antitoxin but is essential to prepare the patient for subsequent injections. By two weeks after the second injection nearly all individuals show a concentration of antitoxin in their blood, which is supposed to afford adequate protection; that is, at least 0.1 of a unit of antitoxin per c.c. of serum. In a recent study by Gold only one person out of 200 failed to have this desired amount within two weeks after the second inoculation. A third subcutaneous injection of 1 c.c. of toxoid is certain to raise the titer of antitoxin in the serum well above the protective level. This level is maintained for a period varying from three months to two years.

The most important feature of active immunization by tetanus toxoid is that once a patient has had the three subcutaneous injections, at properly spaced intervals, he is apparently prepared so that at any subsequent time, a fourth injection will rapidly raise the titer of antitoxin in his serum to a level which is absolutely capable of protecting him from tetanus. This ability of the patient to respond quickly to a fourth injection is known to exist at least five years after the preparatory course was given. It is likely that it exists throughout the life of the patient, but one cannot be certain of this point. Furthermore, the response to the fourth or to subsequent inoculations is so prompt that no antitoxin need be given. Indeed, it seems likely in most individuals, the response to the third injection is sufficiently quick to afford adequate protection from an injury received at the time of injection, but one cannot take chances with this disease, and for the present it is necessary to insist that active immunity cannot be relied upon until one week has elapsed after the third subcutaneous injection of toxoid.

Reactions. Inasmuch as purified alum-precipitated tetanus toxoid contains no serum, it evokes no allergic reactions. Gold[2] has treated allergic patients as well as normal ones, and in over 1000 injections has had only one systemic reaction (hives). Cooke has reported one instance of asthma coming on after an injection of toxoid, but one cannot be certain that this was not simply a coincidence.

It is well known that diphtheria toxoid is poorly tolerated by many adults, but this is not the case with tetanus toxoid. Aside from a slight induration and soreness at the site of inoculation no undesirable effects are recorded.

Improved Technic of Administration. Dr. Herman Gold of Chester, Pennsylvania has developed a most helpful improvement in the technique of administering toxoid. He has shown that after two subcutaneous injections a person will respond to *intranasal instillations* of toxoid just as promptly as to additional subcutaneous injections. His paper is in the process of publication, but he has been kind enough to give the writer access to his data. From Gold's work it seems certain that after a basal active immunity has been established by two subcutaneous injections of toxoid, the titer of antitoxin in the patient's serum can be raised just as effectively by intranasal instillations of toxoid, as it can by further injections. He has replaced the third subcutaneous inoculation by two injections into each nostril of about 0.1 c.c. of topagen.* The nose need not be prepared and the instillation can be carried out in the presence of an upper respiratory infection. It should be repeated successively for two or three days.

* Topagen is a suspension in glycerin of a highly purified and concentrated toxin. It is prepared by Sharp and Dohme.

Indications for Use of Toxoid. Although the data available at the moment may be insufficient to warrant the universal use of toxoid, it is likely that within a short time such data will be available. The present European war will afford a crucial test of its efficacy. Some experimental work suggests that the level of antitoxin in the blood is not the only factor concerned in immunity against tetanus, and it may be that subsequent study will show that actively immunized individuals with less than 0.1 unit of antitoxin per c.c. of serum are actually protected against the disease. For the present it seems wise to urge the development of an active immunity in certain groups of people who are unduly exposed to the risk of tetanus. These groups include farmers, children, the military forces, and some industrial workers. For these individuals who are constantly exposed to the infection we suggest the following schedule:

1. Preparatory inoculation of 1.0 c.c. alum precipitated toxoid subcutaneously.
2. From six weeks to three months later a second similar inoculation.
3. Six weeks later 0.1 c.c. topagen in each nostril for two days.

One week after this treatment the individual will have an effective active immunity which will last for a period of three months to many years. Thereafter one can either give topagen intranasally after every suspicious injury, or one can maintain an effective titer in the serum by repeating the intranasal topagen every three months. In infants it is advisable to give tetanus toxoid along with diphtheria toxoid. Experiments are being carried out to see if it is possible to substitute the intranasal instillations for the preparatory subcutaneous injections, but at present there are no data to justify this change.

THE TREATMENT OF TETANUS

In view of recent experimental work it seems that the treatment of this disease is on a more rational basis than formerly. The present conception of the pathogeny of tetanus can be summarized as follows: The toxin formed by Clostridium tetani is absorbed by lymphatic and venous channels, and thereby reaches the motor end organs and the motor cells in the spinal cord and medulla. There is no conclusive evidence that the toxin passes up the peripheral nerves. The stiffness and rigidity that occur in a case of local tetanus are due to the action of the toxin on the motor end organs. The clonic convulsions of tetanus are due to the poisoning of the anterior horn cells. It is possible experimentally to produce each of these forms of the disease separately.[3,4] It has been shown that after tetanus toxin teaches the anterior horn cells it becomes fixed (i.e., unrecoverable), and that following this there is an incubation period before symptoms occur. It seems clear that during this period the toxin becomes altered in such a way that it is no longer neutralized by antitoxin and that this altered toxin is the common cause of death in cases of tetanus. Occasionally patients die from the fixation of the muscles of respiration or from spasm of the pharyngeal muscles.

As a consequence of this conception the following treatment of clinical tetanus is suggested:

1. An initial intravenous dose of 50,000 units of antitetanic serum.
2. Infiltration by multiple injections of 10,000 units of antitetanic serum around the site of injury.
3. An hour after this local injection the offending wound should be excised.
4. Daily injections of 5,000 units of antitoxin.
5. Sufficient fluids, preferably by mouth or through a nasal tube, to keep the patient in fluid balance.
6. Adequate nourishment.
7. Control of convulsive seizures by the use of paraldehyde, chloral, or ether-oil (per rectum).
8. The use of a respirator when necessary.
9. Tracheotomy, if there is laryngeal spasm causing suffocation.

A few words of explanation about certain of these suggestions are necessary. The initial dose of antitetanic serum is aimed at neutralizing the toxin that is circulating in the blood stream and also that portion of toxin in the cord which has been fixed but not yet altered. Obviously, it is mere guesswork as to how much toxin there is in the blood of any patient, but 50,000 units of antitoxin are probably sufficient to counteract the circulating toxin in every case. It seems unnecessary to give enormous doses of antitoxin, for it has been shown experimentally that if one full lethal dose has been altered in the spinal cord, a million neutralizing doses of antitoxin do not save the animal.[5] It is emphasized, however, that no one can tell whether or not the symptoms of central intoxication are due to a fraction of a lethal dose or to several such doses; therefore it is imperative to give a fairly large initial intravenous dose of antitoxin.

The second recommendation, namely, the infiltration of antitoxin around the causative wound an hour before excision, is important because it effectively prevents the escape of toxin into the surrounding tissues. A case of local tetanus developing after the neglect of this precaution has been described.[6]

The daily injection of 5,000 units of antitoxin is done to maintain the titer in the blood stream and thereby to insure the neutralization of any additional molecules of toxin that may enter it.

The suggestion that the convulsions be controlled by the use of paraldehyde, choral, or ether-oil (per rectum) is based largely on experimental work with dogs. For this species it seems clear that barbiturates and avertin shorten the animal's life if they are given in sufficient quantity to prevent convulsions. The animals used as controls in this experiment were not given any sedatives and survived almost three times as long as those treated with avertin or amytal. The explanation for this observation is that these substances are respiratory depressants. Recently a 9 year old girl was brought to the hospital showing signs of a severe tetanus. The pediatricians who treated the patient were pleased with the effectiveness of paraldehyde (from 8 to 20 c.c. p.r.q. 3 h.), and were surprised at the child's recovery.

The use of a respirator in severe cases of tetanus is certainly indicated. The writer has not had opportunity to try out this device clinically, but, on theoretical grounds, it should be of real value in combating respiratory failures. There are certain instances of clinical tetanus in which death is due to spasm of the laryngeal muscles. In one such case a tracheotomy was performed and artificial respiration employed to revive the patient who ultimately recovered.

There are certain therapeutic measures which we do not recommend: first, the intrathecal injection of antitoxin. Experimentally, we have been unable to demonstrate any superiority of this form of therapy over the intravenous route. Similarly the use of magnesium sulfate does not seem justified. The use of phenol intramuscularly has not been tested in our laboratory, but McClintock and Hutchings[7] were unable to find any beneficial effects whatsoever. We have had no experience with oxygen inhalation therapy in general tetanus, but we have tested experimentally the subcutaneous injection of oxygen for the treatment of local tetanus. This procedure did not alter the degree or the duration of the rigidity.

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THE CHOICE AND USE OF ANTISEPTICS, INSTRUMENTS, SUTURE MATERIALS, DRAINS, AND DRESSINGS IN EMERGENCY SURGERY

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GENERAL CONSIDERATIONS

THE paragraphs that follow are a discussion of various material aids useful in emergency surgery. For our purposes, "emergency surgery" means operations of immediate necessity for traumatic accidents or for suddenly occurring diseases of intrinsic origin conducted in the operating room of a hospital. We here exclude discussion of surgery in mobile field hospitals in wartime or of first aid surgery undertaken in improvised and adverse surroundings.

In general, large hospitals are usually better equipped and more adequately staffed than are small hospitals. With this advantage they are better able to handle emergency surgical operations as part of their routine every day procedure. Small hospitals, lacking as they often do some of the above advantages in material and staff, should be particularly careful to equip their operating rooms with readily available material supplies fundamentally necessary for emergency surgery. Among such necessities are a good operating room light, a safe anesthesia apparatus, a reasonably modern operating table, a small but carefully selected nucleus of best quality instruments, suture material, drains, sponges, linen, gloves, and adequate apparatus for sterilization. It is furthermore an obligation of every general surgeon who does his work in one or more small hospitals to know thoroughly the quality and extent of emergency material available in those hospitals, and to have a small supplemental kit of his own. The latter is especially useful in cases where he is called to a strange hospital. To whatever extent quantity and variety of material aids may have to be curtailed, quality and dependability never should be, for emergency surgery often tests to the limit the ingenuity and ability of all concerned. Never, moreover, should lack of equipment be an excuse either for compromising or abandoning ideal methods of surgical technic. Never should emergency surgery, even that of minor injuries, be thought or spoken of as *minor* surgery.

ANTISEPTICS

A consideration of antiseptics useful in emergency surgery involves their relation to three things: the hands and arms of the surgeon and his assistants, the skin of the patient, and the instruments and other materials used. In all three instances one cannot stress too strongly the necessity and virtues of thorough cleansing and rinsing with soap and water as a preliminary to the use of any antiseptic.

Hands and Arms. For the hands and arms after scrubbing, 70 per cent alcohol offers the best combination of availability, lack of irritation and antiseptic qualities. It is best applied with a saturated sterile gauze sponge. In this way a relatively small amount of alcohol may be kept in contact with the hands and arms for several minutes. If a stronger antiseptic for hands and arms is desired, the use of lime and soda after scrubbing is recommended.

Skin Sterilization. With the single exception of its irritant qualities, tincture of iodine, preferably in 3½ per cent solution, remains the most widely available, inexpensive and dependable solution for sterilizing the field of operation or the edges of a wound. There are also various proprietary preparations of high bactericidal power and with lower irritating properties

than iodine. If one of these is locally available at a reasonable cost, its use as an alternate is certainly not contraindicated. Whatever skin antiseptic is chosen should be used either in alcoholic or alcohol-acetone solution. Great care should be exercised with any antiseptic agent to see that it does not enter freely the cavities of wounds and devitalize living subcutaneous cells. Clean wounds do not need irrigation with antiseptics. If they are contaminated, careful débridement and thorough irrigation with sterile salt solution should suffice. If they are infected, antiseptics in as strong concentrations as are necessary for skin sterilization offer little to assist adequate drainage and the use of Dakin's solution or dichloramine-T.

Instrument Sterilization. For sterilizing or keeping sterile gloves and instruments various antiseptic solutions, especially carbolic acid and bichloride of mercury, have the same fields of usefulness for emergency operations as in surgery of election. Two very useful concentrations are: carbolic 1:20 and bichloride of mercury 1:3000. When there is a decidedly restricted supply of sterile drapes, the use of a 5 per cent carbolic solution in a sterile basin is a practical and safe expedient for temporary placing of sterilized instruments. Such solutions of antiseptics are also necessary for the sterilization of non-boilable catgut and of certain types of instruments.

INSTRUMENTS IN EMERGENCY SURGERY

If a hospital is fortunate enough to have a sufficient quantity of various instruments, it is a great saving of time and confusion to have one complete or nearly complete set segregated in a tray and ready for immediate sterilization at any time. If this is not possible, the list of a "standard emergency set" should be framed where it can easily be consulted at any time. There really should be two lists, one for abdominal operations and one for traumatic surgery, though the number and variety of instruments in each set need not be great. Emergency operations are good opportunities to practice restraint in the number of different instruments used. It is well to remember that Halsted, our greatest American teacher of the lasting fundamentals of surgical technique, used relatively few types of instruments but insisted on the finest quality and a design calculated to minimize trauma to tissues by permitting gentle and delicate use. Realizing that no single list will satisfy all variations of taste and habit, we nevertheless submit the following as having proved useful in a large surgical clinic over a period of many years.

Instruments for Emergency Laparotomies

1. *Scalpels.* Two handles and three or four detachable blades of a single medium size.

2. *Towel Clips.* Six of these will be found the most useful number. One can do with four, and in their absence sterile drapes can always be stitched temporarily to skin or to wound edges.

3. *Thumb Forceps.* One or two of the medium sized mouse-tooth type. The teeth should be of the ½ type and not too long. Another pair without teeth is a useful addition. Lack of teeth, however, does not greatly lessen the amount of trauma done by thumb forceps, certainly as concerns crushing.

4. *Scissors.* Two pairs of Mayo 6¾ inch dissecting scissors, one with straight and the other with curved blades, are enough for all ordinary purposes. The two most useful supplements to these are a pair of special, short, suture-cutting scissors and a pair of long, heavy, curved scissors for use in deep cavities such as the pelvis.

5. *Retractors.* Although Lord Moynihan's dictum[1] still holds, that the hand of an intelligent assistant, gently used, is the best retractor, it is a mistake to handicap oneself by trying to do wholly without instruments for this purpose. Two broad, deep abdominal retractors, either of the rigid or of the flat malleable type, for use with heavily muscled or obese patients, and two smaller, shallower retractors are

about the minimum requirement. In hospitals where the surgeon's assistance is limited to one person, the addition of a self-retaining abdominal retractor to a surgical kit is almost a necessity. In that case, the large retractors, previously mentioned, may be dispensed with.

6. *Hemostats.* If one is willing to exercise some patience in clamping and ligating bleeding vessels a few at a time, no great number of hemostats is needed for emergency operations. At least two types, however, are necessary. The first is a small, straight-bladed clamp 5½ inches in length and with fine points. It can and should be used for hemostasis in all situations where it is not necessary to seize more than the cut vessel itself and the minimum of surrounding tissue. In situations where larger bites of tissue must be taken and firmly held, a larger, longer clamp 6½ inches long and with heavier, longer, 2-inch slightly curved blades is necessary. Eight of each kind will ordinarily suffice. Where cost and bulk of equipment are not prime considerations, a dozen of each establishes a useful reserve. In addition it is essential that there be at least two, and preferably four, longer 8½ inch clamps with curved blades for the control of bleeding from such areas as the splenic pedicle or the depths of the pelvis. Clamps with mouse-tooth ends to their blades cause unnecessary trauma to tissues and should not be used.

7. *Needles.* For suturing skin edges one of several types of straight needle, 2 to 3 inches in length, with either a round, a flat-cutting or a triangular-cutting cross section at its tip, may be selected and kept in stock. The various forms of dermal suture material with swedged-on needles, put up in boilable or presterilized sealed glass tubes, are also useful and handy. For tissues other than skin edges at least one-half dozen each of four kinds of curved needles should be in the emergency kit. The largest of these are half-curved cutting edge needles for inserting tension or stay sutures. Next, there should be three each of similar sizes of full-curved needles of round, non-cutting cross-section. Finally, there should be one-half dozen fine, non-cutting, full-curved ½ inch needles with split eyes, for use in intestinal and other delicate suturing. Additional helps for intestinal suture are straight or curved needles swedged on sterilized catgut and ordinary sewing needles, threaded with short lengths of fine silk. This suggested supply of two dozen or more needles for emergency surgery may seem an extravagant luxury, but needles are neither expensive nor bulky, and are often the most neglected feature of emergency equipment. Of all instruments, moreover, they are the most easily broken, lost and dropped.

8. *Needle Holders.* Two standard 6½ inch needle holders and one longer 8 inch holder for deep wounds are sufficient.

9. *Tenaculum Forceps.* Of these, two three-toothed vulsellum forceps are enough, and much more useful than the Allis forceps usually included. The omission of Allis forceps, furthermore, relieves one of the temptation to seize intestines with them.

10. *Suction Apparatus.* A blunt suction-tip and sufficient heavy rubber tubing are essential parts of emergency equipment wherever built-in or portable suction apparatus is available.

11. *Intestinal Clamps.* Of these there are almost infinite varieties. Most useful are (1) the Rankin[2] three-bladed clamp; (2) the Payr[3]-type crushing clamp; and (3) the Furniss[4] clamp, either in its original form or the smaller McClure[5] modification.

12. *Miscellaneous Instruments.* Here again we could make a long list, but only six items need be mentioned as essentials. These are: (1) a trocar and cannula; (2) a blunt dissector; (3) a grooved director; (4) a uterine probe; (5) a gallstone scoop; (6) gallstone forceps.

Instruments for Emergency Treatment of Accidental Wounds

1. *Scalpels.* A detachable-blade scalpel handle of small size, with both curved and bayonet blades, is the most useful.

2. *Towel Clips.* Should be of small size. Four usually suffice.

3. *Thumb Forceps.* One pair of medium size and one pair of small size with fine teeth. One or two very fine, one- or two-toothed steel hooks are extremely useful at times, instead of thumb forceps, for gentle handling of delicate skin edges or deeper structures.

4. *Retractors.* One pair of small blunt rake retractors for wound edges. One self-retaining (mastoid) retractor for use where assistance is lacking.

5. *Scissors.* One pair each of 5½ inch curved and straight Mayo dissecting scissors and one pair of small sharp-pointed ophthalmologic scissors should be provided.

6. *Hemostats.* One-half dozen small straight 5½ inch (Halsted) clamps and one-half dozen even smaller, finer 5 inch "mosquito" clamps with ¾ inch blades.

7. *Needles and Holders.* Four small fine full-curved cutting needles. Four split-eye, non-cutting needles of same size. Small straight needles of suitable size for skin closure and also for vessel suture should be included.

8. *Miscellaneous Instruments.* Several Allis clamps are useful as adjuncts to retractors. There should also be one probe and one small grooved director and a blunt dissector in the set for traumatic emergencies. There should be at least four bone instruments: a Gigli saw, a rongeur forceps, a sharp curette, and a periosteal elevator, each of medium to small size. An irrigation can with tubing and a fine nozzle is an almost indispensable adjunct to the traumatic emergency kit.

SUTURES AND LIGATURES

Indications for or against the use of one or another type of suture or ligature material are very much the same in emergency surgery as they are in surgery of election. The question admits of discussion from many angles but for the purposes of this brief article may best be considered in terms of the three ways in which sutures and ligatures can be used. They can be buried in the tissues with no intention of removal. They can be used to approximate the edges of wounds. They can be used as temporary tension sutures.

1. *Buried Suture Material.* Silk is mentioned first, not because it should necessarily be used, but because its use should always be considered and favored before deciding to use absorbable sutures. Where the entire operation can be conducted in a "clean" field, silk is the suture material of choice, either in its common twist form or in its braided form. Where the field of operation can be rendered clean, as in the débridement within six hours of a lacerated wound, silk sutures and ligatures again interfere less with satisfactory healing than does catgut. The weight of silk used should be the finest that can be tied without too frequent breaking. It should be of a quality that can be boiled for at least twenty minutes immediately before operation without affecting its tensile strength. Recent developments in the manufacture of very strong yet very fine pliable steel wire offer another type of non-absorbable suture that does not supplant silk but which may sometimes be useful.

Where emergency surgery must be conducted in an obviously infected or seriously contaminated field, it is best to use absorbable suture material. Catgut has long been offered to the profession in a bewildering assortment of sizes and types of preparation. It would not be helpful here to endeavor justly to "choose sides" between these types. Instead, a few considerations will be offered that are sometimes overlooked or discarded in the hurry of preparation for emergency surgery. First, it is reasonable to assume that firms who have been preparing surgical catgut for a period of years are conscientious in their efforts toward perfect sterilization and honest in their advertised claims. One cannot, however, place equal confidence in claims as to rate of absorption. Second, it is well to remember that,

granted sterility in both cases, catgut treated to withstand digestion will be absorbed by the contiguous tissues with far less reaction, though more slowly, than untreated catgut. Third, it is a fallacy to assume that one is "playing safe" by using heavier catgut in emergency operations than one would ordinarily use. The 000, 00 and 0 should be the grades of choice, with occasional resort to No. 1 grade. Fourth, it is well to have in the emergency kit a supply both of boilable and non-boilable catgut.

2. *Skin Sutures.* For the approximation of the skin edges of a wound, very fine non-absorbable, non-irritating suture material is clearly superior to any type of absorbable material. For very delicate work, fine horsehair or an equally fine weight of one of the various synthetic dermal sutures is the ideal material. There will be less trauma if the needle is swedged on the suture instead of being threaded. For ordinary use in emergencies, however, the non-irritant qualities of fine silk so closely approximate those of horsehair and dermal suture that the greater cheapness and availability of silk make it the material of choice for skin sutures.

3. *Stay Sutures.* If stay or tension sutures are desired for helping to close the wound of an emergency operation, there is no reason for choosing material other than what one prefers for operations of election. The material chosen should be non-absorbable. In contrast to what has been stressed above, the size of the suture, whether it be silkworm gut, braided silk, synthetic suture material, steel wire or silver wire, should be *large.* Large size is advocated not because of increased tensile strength but because it tends less to cut through tissues by pressure necrosis. Whether stay sutures be placed through all or only the upper layers of a wound is best left to the discretion of the surgeon. They should never, however, be tied with too great tension of their own in an effort to relieve tension on other suture lines.

DRAINS

In an article of this kind there is properly only one thing to emphasize about drains. If a drain must be used in an emergency laparotomy for any purpose other than to tap a duct or hollow organ, there is no question of the great margin of safety in the use of a soft rubber dam or gutta-percha tissue drain over any other type of rubber tubing or other material. Where small wounds must be drained, strips of thin gutta-percha, ordinary rubber bands, and even small twists of silk or chromicized catgut are useful substitutes for rubber dam. Whether rubber dam is used alone, or as a so-called "cigarette" drain of gauze folded within rubber dam, is a matter for the individual surgeon to decide. Drains should be sewn to the skin edge as soon as they are placed in a wound, not only to help prevent their coming out but more particularly to prevent their accidentally disappearing within a wound and becoming overlooked and forgotten.

DRESSINGS

Under this heading should be considered both the gauze sponges used at emergency operations and the dressings for covering the wound at the conclusion of the operation.

Accidental Wounds. The use of sponges in the surgical care of accidental wounds other than abdominal presents few problems. Two or three things, at least, should be remembered. One is to standardize on one size of gauze sponge, preferably the 3-inch square, folded once. Another is that a gauze sponge wrung out in sterile physiologic saline solution causes less tissue trauma and avoids dealing with a "sticky" wound. Third, if air suction is easily available, a small glass suction tip such as is used in brain surgery is useful in conjunction with irrigation of the wound to save sponging. Fourthly, the careful use of a tourniquet during operations on the extremities greatly reduces the need for

sponging and to that extent saves tissue trauma.

Emergency Laparotomies. The choice and use of sponges for emergency laparotomies involves much more important problems. Safeguarding against loss of a sponge within the abdominal cavity is a paramount consideration. It follows from this that a single, or at most two standardized sizes and types of hand sponge are the easiest to count and to handle. Suggested for one of these is a folded gauze sponge 8 × 6 inches, made from a single piece of gauze 36 × 24 inches, and eight layers thick when folded. The other is a so-called Mikulicz pad 12 inches square, made of several layers of gauze sewed together and with a telltale of half-inch cotton tape, to which can be attached a clamp or ring. Each of these sponges is of a size not likely to be overlooked in an abdominal wound. It should be a rule, however, to wait for the sponge count in emergency operations before starting to close the peritoneum, double checking with a formal search of the wound for any stray sponges at the time the count is being made.

Of the dressings to be used at the conclusion of operations little need be said save that they should neither be too tight nor too bulky. Splints should be available for use in operations on the extremities whether a fracture is involved or not.

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STUDIES ON HEXYL-CHLORO-M-CRESOL AND OTHER CARBOCYCLIC ANTISEPTICS*

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ALTHOUGH the terms antiseptic and disinfectant are generally understood and defined by all, Patterson[1] points out that historically both were coined and used before there was any exact knowledge of bacteria. Sir John Pringle introduced the term antiseptic in 1750 and applied it to substances preventing putrefaction. The Federal Food and Drug Act of 1928 stated that salves, ointments and dressings which remain in contact with the body for long periods were to be considered antiseptics if they inhibited bacterial growth. On the other hand, mouthwashes, gargles, douches and preparations for similar uses (skin preparations) which were in contact for but a brief period of time were to be considered antiseptics only if they killed bacteria in the dilutions recommended and in a comparatively short time. The statement of the Food and Drug Act would make the words disinfectant and antiseptic synonymous in most of the present day applications. Perhaps it is for this reason that most of the substances used by both the public and the medical profession for antiseptic or disinfectant purposes are spoken of as germicides or as possessing certain germicidal activity.

Relatively little is proved regarding the mechanism of disinfection. Pringle, in 1750, first advanced the theory that it was associated with coagulation of protein. Ward, almost 150 years later, gave the first objective evidence supporting Pringle. The modern statement of this theory may be quoted from the work of Wilder D. Bancroft and G. Holmes Richter:[2] "Disinfection in the light of colloid chemistry indicates that antisepsis is merely a state of narcosis, which depends upon the reversible coagulation of the cell colloids; disinfection is brought about by the irreversible coagulation of the cell colloids." Objection is brought to the coagulation theory that there should be a parallelism between the coagulation of plant and animal proteins and that many of our more active inhibiting or destructive agents do not coagulate animal proteins. In fact, one of our ideals is to find an agent which has a selective bactericidal property but does not destroy the tissue cells.

Whatever theory we adopt or is finally proved correct, we have at present a good knowledge of many of the factors controlling the actual process of disinfection and antisepsis. They may be listed as follows:

A. Concentration of organisms and time. A bacterial suspension exposed to a disinfectant shows a gradual decrease in the number of living cells, the number dying during any period being a certain fraction of the number living at the beginning of the exposure.

B. Concentration of disinfectant. The greater the amount of chemical originally added the more rapid the destruction.

C. Medium in which the disinfectant acts. The presence of organic material in the suspension usually decreases the activity of the disinfectant and acidity increases it.

D. The type of organism. Activity of a substance against one organism or one group of organisms gives no clue to the activity against another group. The F. D. A. method includes the use of *S. aureus* and *E. typhi* and most simple substances showing satisfactory killing power against one are weak against the other. This explains the necessity of using complex chemical compounds or mixtures of two different chemical groups.

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E. The criterion on which death is based. Organisms may grow on artificial media after exposure to a disinfectant but fail to infect animals. The organism is more apt to show survival on enriched media and at 37°c. Death or survival therefore may depend on the test employed.

The present study was stimulated by a desire to find a substance of high bactericidal activity and low tissue toxicity to be used in conjunction with tannic acid in the treatment of burns. The studies of Salle and Lazarus[3] on the "toxicity index" of antiseptics indicated that most of the substances now in use were too destructive to tissue cells to be used on large burned surfaces where uninjured cells must be preserved and given proper conditions for growth.

Obviously, general systemic toxicity was to be avoided even more than local tissue toxicity; hence the salts of heavy metals and phenol were considered unsuitable despite their use by some manufacturers in very low concentrations of questionable bacteriostatic value.

Having used various tricresol derivatives in the preparation of bacterial vaccines and being impressed with their sterilizing action and their low toxicity on subcutaneous injection, we thought the use of this group as an antiseptic combination with tannic acid logical. Utilizing the F. D. A. method of testing, amyl-tricresol in solutions made up with water 25 per cent, alcohol 25 per cent, and glycerine 50 per cent, was found effective against *S. aureus* in ten minutes in 1:4000 dilution and against *E. typhi* in 1:2000. However, a similar solution containing 5 per cent tannic acid became effective in dilutions of 1:28,000 against *E. typhi* and 1:24,000 against *S. aureus*. As pointed out in a preliminary note[4] this increased activity was due for the most part to the lowering of the *pH*, although some acids, such as hydrochloric, increase the activity proportionately more than other acids tried.

The tannic acid-tricresol preparations were tried on burned surfaces, but produced some irritation when first applied and were abandoned although the wounds remained free of infection and healing was satisfactory. The partial success with these cresols led to trial of many related compounds,[4] but the cresol base with the incorporation of a hexyl radical and one or more chlorine radicals remains the most effective antiseptic.

In 1921, Johnson and Lane[5] systematically investigated the influence of the introduction of alkyl groups on the antiseptic properties of resorcinol. They found that the antiseptic value of resorcinol is markedly increased by the introduction of an alkyl group into the nucleus and further that the increase is related to the size of the group introduced. For example, if the phenol coefficient of resorcinol is placed arbitrarily at 1.0, the introduction of an ethyl group raises the coefficient to 4.9, the introduction of an n-propyl group raises the coefficient to 13.8 and the introduction of an n-butyl group raises the coefficient to 25.6.

Following the lead of Johnson and Lane, Dohme, Cox and Miller[6] extended the alkyl series of resorcinol to the dodecyl derivatives and their tests showed a steady rise in the phenol coefficients with the size of the alkyl group introduced, reaching a peak with the hexyl derivatives.

In the synthesis of all these alkyl resorcinols the method used was that of Nencki and Sieber[7] which consists in the condensation of corresponding fatty acids with resorcinol in the presence of zinc chloride. The ketones thus obtained are reduced with zinc amalgam and hydrochloric acid according to Clemmensen's[8] method.

Another method of increasing the antiseptic activity of carbocyclic compounds, second only to the introduction of alkyl groups, is the introduction of halogens. This method, though known for some time, has been utilized chiefly by Klarmann and his associates[9] in the production of several chlorophenols.

Working along the lines mentioned above, many carbocyclic derivatives have been synthesized, including seven apparently new hydroxy-chloro-alkyl-benzenes, namely 4-chloro-6-hexyl-resorcinol, 4-6-dichloro-2-hexyl-resorcinol, 6-chloro-4-hexyl m-cresol, 4-6-dichloro-2-hexyl-m-cresol, iodo-mercuri-hexyl-chloro-m-cresol, bromo-hexyl-chloro-m-cresol, and 2-4-dichloro-6-hexyl phenol. All seven of these derivatives are highly effective antiseptics but we wish to emphasize but two (dichloro-hexyl resorcinol and hexyl chloro-m-cresol) in this paper since only these have received an extensive clinical trial as well as exhaustive laboratory tests.

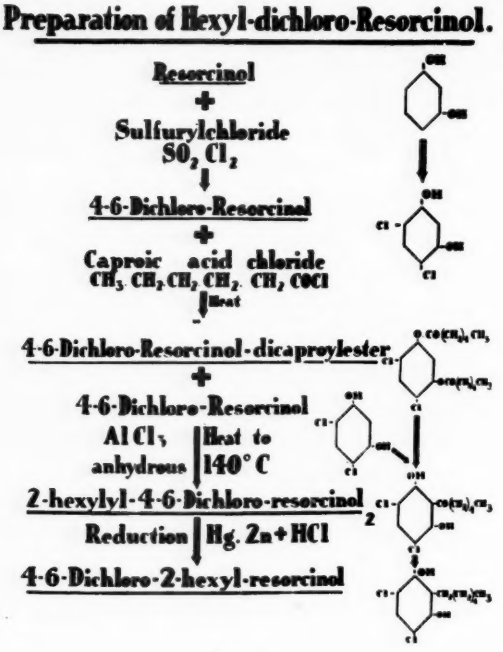


Fig. 1.

Methods of Preparation

4-6-Dichloro-2-Hexyl Resorcinol. Resorcinol is chlorinated in ether solution with sulphuryl chloride according to the method described by Moore, Day and Suter.[10] The resulting dichloro-resorcinol is distilled under reduced pressure. It is a white crystalline substance, melting point 112–113°C. The dicarproylester of this compound was formed by the action of 2 molecules of caproylchloride for 1 molecule of dichloro-resorcinol. This compound, when distilled in high vacuum, is a clear oil. The Rosenmund and Schnurr[11] rearrangement reaction with Al Cl_3 was applied to the diester. Advantage was taken of the obser[2]vation of Stoughton, Baltzly and Bass[1] that the second alkyl group of the diester in the rearrangement of di-hydroxi-benzenes can be included in the reaction by adding 1 molecule of the free phenol. The proportion of the reacting substances in this case was accordingly as follows: 1 molecule of dichloro-resorcinol-dicaproylester, 1 molecule dichloro-resorcinol and 2.2 molecules anhydrous Al Cl_3. The resulting ketone hexylyl-dichloro-resorcinol is distilled in high vacuum. It is a yellowish oil which easily crystallizes in the cold (melting point 102°C.). The ketone is reduced with amalgamated zinc and HCl (Clemmensen) to the corresponding alkyl compound. 4-6-dichloro-2-hexyl-resorcinol distills in high vacuum at 174–177°C. It is a colorless liquid which on cooling crystallizes to a white mass (melting point 52°C.).

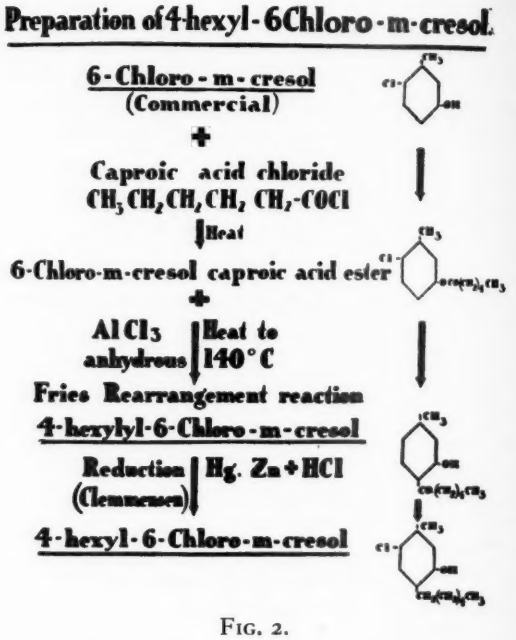


Fig. 2.

6-Chloro-4-Hexyl-M-Cresol. The starting material for this compound is the commercial chloro-m-cresol (2-chloro-5 hydroxytoluene Eastman). By the interaction of 1 molecule of this compound with 1 molecule caproylchloride the caproylester

is obtained. It is a clear liquid (boiling point 184–187°c. at 20 mm.). One molecule of the ester is heated with 1.2 molecule Al Cl_3 for one hour at 140–160°c. After the decomposition of the melt with concentrated HCl, the ketone is obtained as a solid mass. It is reduced according to Clemmensen with amalgamated zinc and HCl to the corresponding alkyl compound. This is a colorless oil when distilled under high vacuum (boiling point 148–150°c.) and crystallizes to a white mass in the cold.

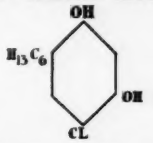
One difficulty with the carbocyclic group as a whole is the low solubility in water. None of them show a solubility in water of more than 1:2000. Solvents containing glycerine, neutral soap, alcohol and propylene glycol have given the best solutions. Frequently a satisfactory clear solution is again turned into a suspension when further dilution with water is attempted. Three solutions have been used in testing, glycerine 35 per cent, alcohol 25 per cent, and water 40 per cent; glycerine 20 per cent, duponol .33 per cent, water 80 per cent; and propylene glycol 35 per cent, alcohol 25 per cent, and water 40 per cent. For wound antisepsis or mucous membranes a solvent of propylene glycol 40 per cent, duponol .1 per cent and water 60 per cent is recommended. For skin preparation a solvent of alcohol 50 per cent, acetone 10 per cent, and water 40 per cent. Suspensions of various substances in glucose 20 per cent, duponol .1 per cent, alcohol 1 per cent have been used experimentally in animals.

LABORATORY TESTS

In accordance with present accepted standards the method of testing antiseptics for activity against bacteria recommended by the U. S. Food and Drug Administration,[13] including the Shippen modification, was employed throughout. The strains of *S. aureus* and *E. typhi* were those furnished by the F. D. A.

Comparison of the resistance of bacteria and embryonic tissue to antiseptics (the toxicity indices) was carried out by the original method of Salle and Lazarus.[3] Nye[14] has criticized this method and it has now been modified.[15] Whether fundamentally

6 Hexyl-4-chloro Resorcinol



1-2000 Sol Glycerine 20% Duponol .33% in H_2O
F.D.A. Method - Shippen mod. Salle & Lazarus Method

Highest dil kills in 10 min. not in 5		Tissue culture	Toxicity index	
A	B	C	C/A	C/B
S.aureus	E.typhi			
22,000	1000	7000	.31	7.0
plus .36% Hcl				
30,000	15,000			

1-2000 Sol Glycerine 50% Alcohol 25% H_2O 25%

28,000	2000
plus 5% tannic acid	
36,000	24,000
plus .36% Hcl	
68,000	48,000

Fig. 3.

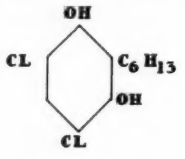
valid or not, the results obtained are relatively accurate and are presented merely for comparative evaluation.

Hexyl-Chloro-Resorcinol. This is a colorless heavy liquid or a white amorphous substance sparingly soluble in water but readily soluble in alcohol and propylene glycol. As indicated in the chart, solutions are made either with glycerine and a neutral soap (duponol) or with glycerine and water. Solutions for use as a skin antiseptic are made up with alcohol 50 per cent, acetone 10 per cent, and water 40 per cent. Using the Shippen modification of the F. D. A., this material killed *S. aureus* in dilutions of 1:22,000 and *E. typhi* in dilutions of 1:1000 in ten minutes. Cultures of chick heart were inhibited in dilutions of 1:7000, giving a toxicity index of .31 with *S. aureus* and 7.0 with *E. typhi*. The addition of 0.36 per cent HCl to this solution resulted in increasing the killing dilutions of 1:33,000 with *S. aureus* and 1:15,000 with *E. typhi* in ten minutes.

Solutions made with glycerine, alcohol, water, including .36 per cent HCl, are still more active, being effective in ten minutes against *S. aureus* in dilutions of 1:68,000 and against *E. typhi* in dilutions of 1:48,000.

This difference in the two solutions is due to the neutralizing effect of the neutral soap in the first instance. This product has been

Di chloro - Hexyl Resorcinol



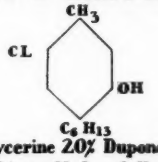
1-1000 Sol. Propylene Glycol 35% alcohol 25% H_2O 40%

F.D.A. Method - Shippen Mod.		Salle & Lazarus Method		
Highest dilution kills in 10 but not in 5 min.		Tissue culture	Toxicity index	
A	B	C	C/A	C/B
S. aureus 40000 plus .36 Hcl	E. typhi 1500	3500	.08	2.3
90000	44000	7000	.07	.14

Fig. 4.

but is readily soluble in alcohol and propylene glycol. For antiseptic purposes a watery solution is made with glycerine

4 Hexyl - 6 - chloro-m-cresol



1-2000 Sol. Glycerine 20% Duponol .33% H_2O 80%

F.D.A Method - Shippen Mod.		Salle & Lazarus Method		
Highest dil. kills in 10 min. but not in 5 min.		Tissue culture	Toxicity index	
A	B	C	C/A	C/B
S. aureus 70000 plus .36% Hcl	E. typhi 400	1300	.019	3.
190000	4000	4000	.02	1.

1-2000 Sol. Glycerine 20% alcohol 25% H_2O 55%
plus tannic acid 5%

124000	4000
plus .36% Hcl	
200000	36000

Fig. 5.

used clinically where watery solutions were desirable because of its solubility, especially in solutions and jellies used in combination with tannic acid for the treatment of burns. The tissue toxicity is low, as indicated by tissue culture method, animal inoculation and clinical observation.

4-6-*Dichloro-2-Hexyl-Resorcinol.* This material is similar in physical characteristics to hexyl-chloro-resorcinol except that it is somewhat less soluble in water. In the propylene glycol alcohol solution indicated in the chart it is effective in ten minutes against *S. aureus* in dilutions of 1:40,000 and against *E. typhi* in dilutions of 1:1500. Cultures of chick heart are inhibited in dilutions of 1:3500. The resulting toxicity indeces are .08 with *S. aureus* and 23 with *E. typhi.* Adding .36 per cent HCl to the solution it is effective in ten minutes against *S. aureus* in dilutions of 1:90,000 and against *E. typhi* in dilutions of 1:44,000. Chick heart cultures are inhibited in dilutions of 1:7000, thus toxicity indices are .07 with *S. aureus* and .14 with *E. typhi.*

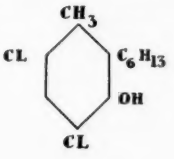
4-*Hexyl-6-Chloro-M-Cresol.* This material is a heavy, colorless solution when warm, but grayish-white crystals when cold. It is only moderately soluble in water 20 per cent, duponol .33 per cent, alcohol 10 per cent and water 69.67 per cent. An alcoholic solution for skin preparation is made up with alcohol 50 per cent, acetone 10 per cent and water 40 per cent.

In watery solution this material kills *S. aureus* in ten minutes in dilutions of 1:70,000 and *E. typhi* in dilutions of 1:400. Chick heart cultures are inhibited by dilutions of 1:1300. The toxicity indices produced are .019 with *S. aureus* and 3 with *E. typhi.* The addition of .36 per cent HCl to this watery solution increases the effectiveness to dilutions of 1:190,000 with *S. aureus* and 1:4000 with *E. typhi.* The toxicity indices are also changed to .02 with *S. aureus* and 1 with *E. typhi.*

In alcoholic solutions or glycerine and alcohol solutions this substance is more active, especially when made up with .36 per cent HCl, killing *S. aureus* in ten minutes in dilutions of 1:200,000 and *E. typhi* in dilutions of 1:36,000. The indicated effectiveness against the F. D. A. strain of *S. aureus* is, as far as can be ascertained, the highest reported for any chemical with such relatively low tissue toxicity. The killing power in ten minutes of the alcohol acetone solution containing .36 per cent HCl for other organisms

commonly found on the skin was determined as follows: *Es. coli* in dilutions 1:38,000; *B. pyocyaneus* in dilutions of

4-6 Di chloro - 2 Hexyl-m-cresol



1-1000 Sol. Propylene Glycol 35% alcohol 25% H_2O 40%

F.D.A Method - Shippen Mod.		Salle & Lazarus Method		
Highest dil. kills in 10 min. but not in 5 min.		Tissue culture	Toxicity index	
A	B	C	C/A	C/B
S. aureus	E. typhi			
130000	1000	8000	.06	8.
plus .36 Hcl				
200000	5000	10000	.045	2.

Fig. 6.

1:27,000; *Streptococcus viridans* in dilutions of 1:240,000; *Streptococcus hemolyticus* in dilutions of 1:440,000, and *B. welchii* in dilutions of 1:26,000.

Hexyl-chloro-m-cresol is the antiseptic which has been in general use throughout the hospital for three years, having been employed in more than 5000 major and 10,000 minor operations, and 1200 obstetrical preparations. In the clean surgical cases the percentage of infection during the last twelve months has been 0.1 per cent, and the infections were all in scalp wounds. In the obstetrical work no infections in skin wounds have been seen and the postpartum course of the patients has generally been more satisfactory than with the type of preparation previously employed. As a rule a watery solution 1:2000, glycerine 20 per cent, duponol. 33 per cent and water 79.67 per cent is used in wounds and on mucous membranes, while the alcoholic solution 1:1000, alcohol 50 per cent, acetone 10 per cent and water 40 per cent is used in all skin preparations.

4-6-*Dichloro-2-Hexyl-M-Cresol.* This product has physical properties similar to hexyl-chloro-m-cresol and despite the additional chlorine radicals is less active than the mono-chloro-hexyl-m-cresol. It is also less soluble. Numerous comparable attempts to introduce other halogen radicals has failed thus far to improve the derivatives.

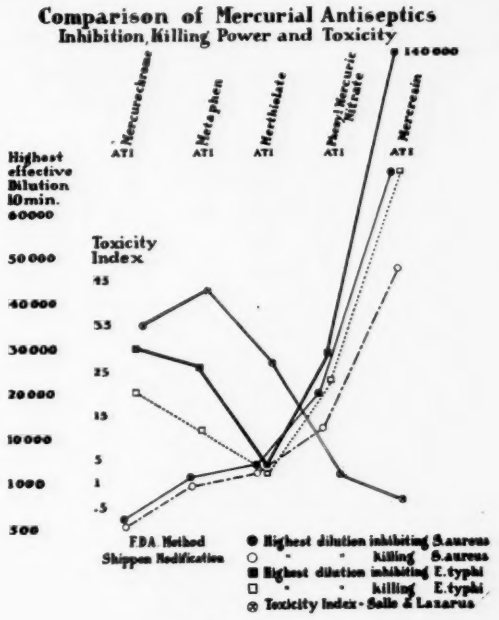


Fig. 7.

DISCUSSION

Of the various carbocyclic antiseptics synthesized and tested to date, dichloro-hexyl-resorcinol and hexyl-chloro-m-cresol are superior. The former has been used particularly in the tannic acid preparation for burns and the latter has been used as a general hospital antiseptic. The clean surgical cases in the general surgical service of Dr. Roy D. McClure, prepared with hexyl-chloro-m-cresol, have not shown a single wound infection in the last twelve months. This excellent clinical record, coupled with the high bactericidal activity and low tissue toxicity of the material, demonstrated in repeated laboratory observations, indicate its acceptability as a general antiseptic.

When comparative evaluation of hexyl-chloro-m-cresol is undertaken, the antiseptics in common use must be listed and tested in the same manner. Probably the six antiseptics in most general use are iodine, mercurochrome, metaphen, merthiolate, phenyl mercuric nitrate, and mercresin. The five mercury compounds

are listed in Figure 7. They are arranged in order of their effectiveness against *S. aureus* and tissue toxicity from left to right. Mercurochrome has the highest toxicity index and is the least effective against *S. aureus*, but is somewhat more active against *E. typhi*, especially as an inhibitor. In view of the high activity of hexyl-chloro-m-cresol it is interesting to note that the most active mercurial (mercresin) against both *S. aureus* and *E. typhi* is not a chemical compound but a mixture of ortho-hydroxy-phenyl mercury-bichloride and five isomeric amyl-ortho-cresols.

Brewer[16] reached the following conclusions among others in a recent study of the mercurials used as antiseptics, including all five of those mentioned above: "To explain the ability of some of the mercurials to act as antiseptics is beyond the scope of this paper. However, their actual germicidal value for vegetative bacteria is questioned. After it was found that the mercurial solutions as commonly used are incapable of killing the spores of the pathogenic anaerobes in twenty-four hours, it was decided to determine their effect on some vegetative bacteria by the centrifuge method. Just as statements are made that some of these mercurials will kill spore-forming bacteria, some of the manufacturers claim that their particular product will kill vegetative bacteria in ten minutes. One of the mercurials used did not kill *Staphylococcus aureus* in thirty minutes, although no neutralizers or special recovery methods were used. Other vegetative bacteria were used and the results indicate that some method other than one based on phenol coefficient determination should be used to establish the ability of the mercurials to disinfect instruments."

As for iodine, the tincture was effective in ten minutes F. D. A. method against *S. aureus* in dilutions of 1:9000 and against *E. typhi* in dilutions of 1:11,000. The toxicity index was 0.1. The principal criticism of iodine is the fact that skin burns not infrequently result if it is left on the skin during the operation or is applied full strength to the axillae, inguinal regions or about the genitalia.

Compared with hexyl-chloro-m-cresol, the mercurials are less effective against *S. aureus* and are much more toxic for tissue cultures. Against *E. typhi* mercresin, containing uncombined amyl-ortho-cresols, is more effective. In comparison, iodine is much less effective against *S. aureus*, somewhat less effective against *E. typhi*, and has a higher toxicity index than the hexyl-chloro-m-cresol in solutions brought to *p*H of 3.

CONCLUSIONS

1. A new antiseptic, hexyl-chloro-m-cresol, is described along with other compounds of the carbocyclic group.

2. These compounds are heavy, colorless liquids or white solids, are practically odorless and are sparingly soluble in water.

3. Dichloro-hexyl-resorcinol and hexyl-chloro-m-cresol are unusually effective bactericidal substances, especially against staphylococci, streptococci, pyocyaneus, and the Gram-negative bacilli when their solutions are acidified to *p*H of three with HCl or other acids.

4. Toxicity, both locally and systemically is comparatively low, hence danger from absorption or ingestion of the 1:1000 solutions is negligible.

5. A highly satisfactory performance in an extended clinical trial coupled with laboratory tests showing low toxicity for tissue cells and unusual effectiveness against bacteria indicates that these substances are most acceptable general antiseptics.

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TREATMENT OF BURNS*

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THROUGHOUT the years few injuries have approximated the sum total of human misery associated with the severe burn. Modern civilization, while increasing the load of pain and death, until recent years has offered little encouragement in the attempt to lessen the suffering resulting from this form of bodily injury. Statistics prove the statement that severe burns constitute one of the most serious hazards of modern times, as regards human existence and well being.

The surgeon confronted by the prospect of treating a seriously burned patient accepts a great responsibility. He must expect to spend countless hours of close attention and supervision, with periods of mixed anxiety and discouragement before the case is terminated, and always present is the grim realization that in spite of all efforts, a fatal outcome may supervene.

It has been said that during the first twenty-five years of the present century, severe burn cases approached the picture of the pre-Listerian or "laudable pus" days.[1] It is an unpleasant memory for many of us to recall the scenes associated with these extensive open wounds, bathed in purulent exudate requiring painful dressings, and all too inadequately treated with salves, ointments, and countless favorite medicaments. All of these, we now realize, added to the patient's suffering and the long period of convalescence.

Medical history has recorded a new era in the management of the severe burn case which may be said to have begun with the introduction of the tannic acid treatment. As stated by Wells,[2] "the introduction of tannic acid by Davidson in 1925 has revolutionized and, apparently for the first time in history, standardized the treatment of diffuse burns." This contribution[3] to medical science has without doubt helped to lower the mortality in this type of case.

It has been through the experiences of workers in this field that the present form of treatment has been developed, as represented by the bibliography and references listed by Harkins[4] in his recent review on the advances in the study of burns. A few of the older principles of treatment have been emphasized, but as our knowledge of physiology and pathology in relation to changes occuring in the human body increased, recent advances have been made which developed a more rational basis for therapy. The interchange of ideas and experiences, together with the emphasis of certain important points, has been most valuable. In accord with this view, a résumé of our present form of management of the severe burn is presented, together with a report of the results obtained. From time to time the method of treatment has been modified as the result of our experience, and in accordance with the suggestions of others. For the most part, we still adhere to the basic principles as proposed by Davidson, while working at the Children's Hospital of Michigan from 1927 until his death in 1933.

GENERAL CONSIDERATIONS

Burns in children account for approximately 45 per cent of the deaths in the United States occurring annually from this type of injury,[5] and thousands of survivors are left with disfiguring and disabling scars. It has often been pointed

* Surgical Service, Children's Hospital of Michigan.

out that the severity of burns in young children is increased by the delicate character of the epithelium. This is reflected in the mortality among young individuals and by the extensive scarring often encountered after healing. It has been noted that the mortality of burns of the face is relatively high. In two of six fatal cases occurring during the year 1938, the burned area was limited almost entirely to the face. There is apparently no adequate explanation for the severe reaction from such injuries. It is also a fact that burns involving the body or trunk are more serious than those of a corresponding size located on the extremities.

The large number of thermal injuries resulting from hot liquids has been mentioned by Davidson[6] in a review of the cases at the Children's Hospital. There has been no material change in this regard (Table 1) in cases treated in recent years,

Table 1
Etiology of Burns
1922–1938

	No.	Per Cent
Hot fluids (spilling hot liquids from table or stove, stepping or falling in hot water)	472	54.1
Fire (bonfire, stove, gas heater, gasoline, etc.)	218	25.0
Fire (results of playing with matches)	64	7.3
Chemicals	37	4.2
Not stated	82	9.4
Total	873	
Considered avoidable	711	81.4
Considered unavoidable	80	9.2
Not stated	82	9.4
Total	873	

and the age incidence (Fig. 1) remains practically unchanged.

Experience leads us to believe that the success attending the care of a severe burn case is in part dependent on the time interval elapsing between the injury and the institution of surgical treatment. Of equal importance is the condition of the burned surface when the patient is admitted. It is apparent that the efforts of those interested in the treatment of burns have had some effect in bringing about the

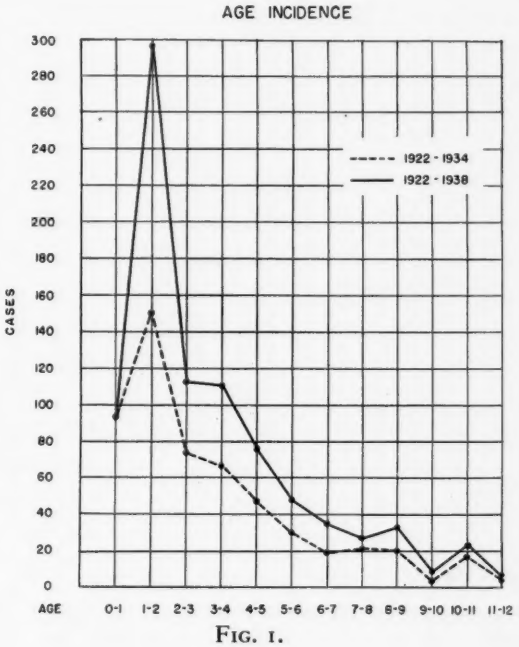


Fig. 1.

earlier hospitalization of many of these patients. Approximately 60 per cent of the burn patients admitted to the Children's Hospital of Michigan in the years 1934 to 1938 entered within 24 hours of the time of injury, as compared with 40 per cent admissions on the first day in the years 1930 to 1934. In many cases the importance of instituting prompt hospital treatment was recognized by the parents or attendants. The physician first called to see the patient also recommended immediate hospitalization, the only treatment given being the application of a sterile dry dressing and a sedative. The resultant saving of valuable time is reflected, we believe, in the more favorable mortality figures. Much is still to be desired in the education of the laity regarding prevention and the early hospitalization of the severely burned patient.

Investigators have determined that there are changes in the character of the blood in patients suffering from severe burns. Following a diffuse burn, there is hemoconcentration,[7,8,9,10,11] loss of blood plasma and

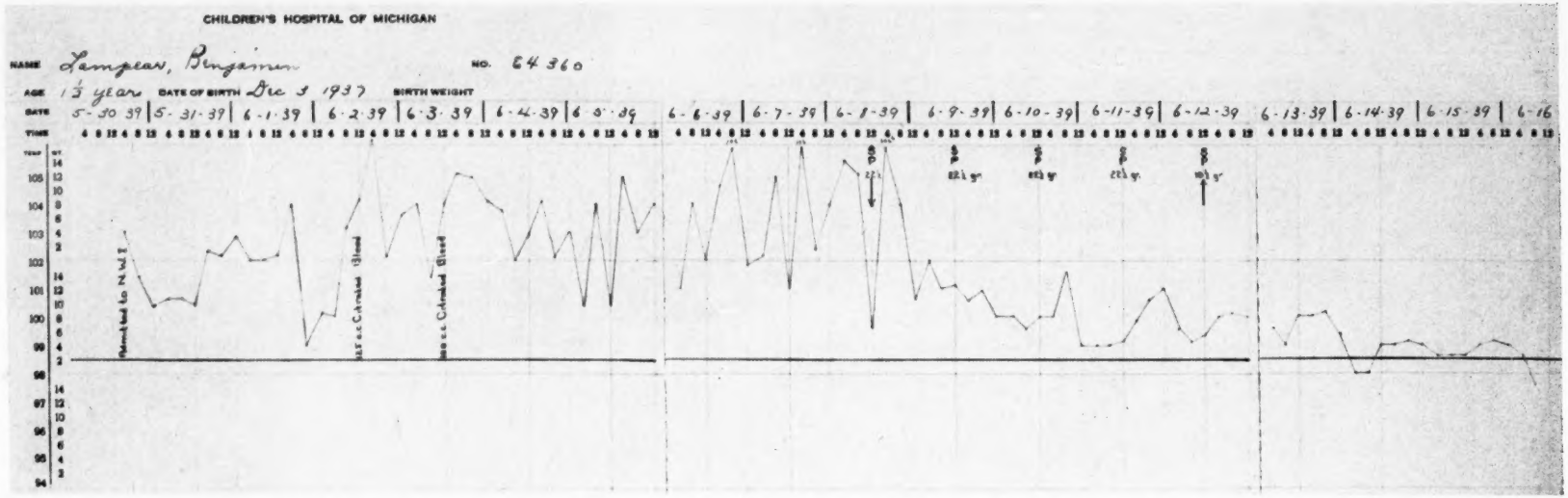
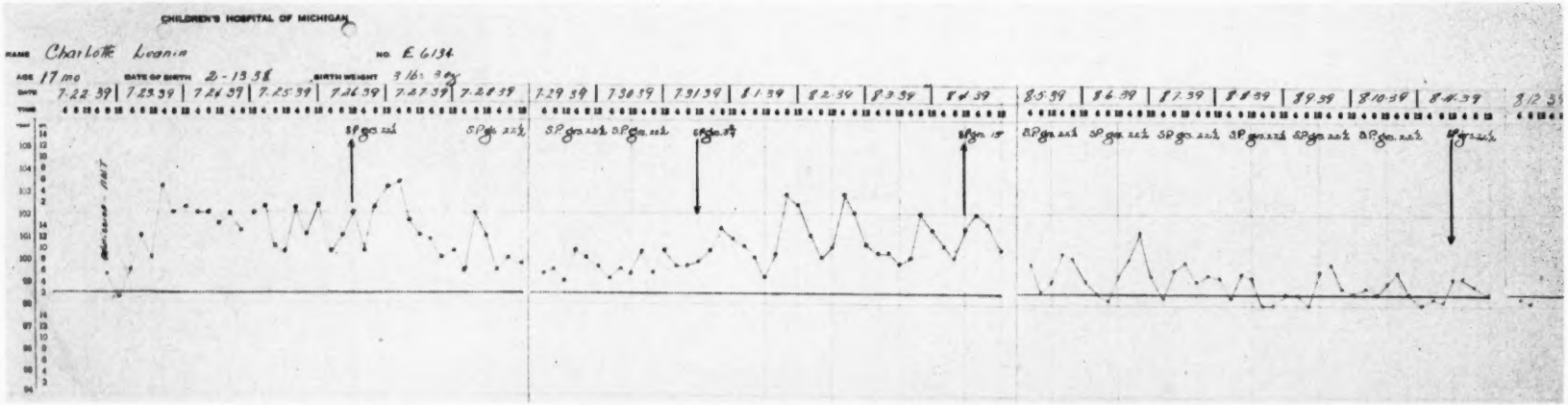

CHILDREN'S HOSPITAL OF MICHIGAN
NAME Lampeau, Benjamin NO. 64360
AGE 1½ year DATE OF BIRTH Dec 3 1937 BIRTH WEIGHT
DATE 5-30-39 | 5-31-39 | 6-1-39 | 6-2-39 | 6-3-39 | 6-4-39 | 6-5-39 | 6-6-39 | 6-7-39 | 6-8-39 | 6-9-39 | 6-10-39 | 6-11-39 | 6-12-39 | 6-13-39 | 6-14-39 | 6-15-39 | 6-16
TIME
Admitted to N. W. E.
Cc. Citrated Blood
Cc. Citrated Blood
22½ gr.
22½ gr.
22½ gr.
11¼ gr.

FIG. 2. B. L., male child, 1½ years of age, was admitted May 30, 1939, suffering from extensive second degree burns, and 5 per cent tannic acid and 1 per cent gentian violet solutions were applied to the burned areas. Evidence of toxemia, with a high temperature, was present on the tenth day. Sulfapyridine, 22.5 gr., was administered in divided doses each twenty-four hours for a period of four days. There was an abrupt decline in temperature and marked improvement in the general condition. The patient was discharged on the sixteenth day.


CHILDREN'S HOSPITAL OF MICHIGAN
NAME Charlotte Leonia NO. E 6134
AGE 17 mo DATE OF BIRTH 2-13-38 BIRTH WEIGHT 9 lbs 3 oz
DATE 7-22-39 | 7-23-39 | 7-24-39 | 7-25-39 | 7-26-39 | 7-27-39 | 7-28-39 | 7-29-39 | 7-30-39 | 7-31-39 | 8-1-39 | 8-2-39 | 8-3-39 | 8-4-39 | 8-5-39 | 8-6-39 | 8-7-39 | 8-8-39 | 8-9-39 | 8-10-39 | 8-11-39
TIME
SP gm. 22½
SP gm. 22½
SP gm. 22½
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SP gm. 15
SP gm. 22½
SP gm. 22½
SP gm. 22½
SP gm. 22½
SP gm. 22½
SP gm. 22½
SP gm. 22½

FIG. 3. C. L., female child, 17 months of age, was admitted July 22, 1939, suffering from extensive second degree burns. The involved areas were treated with 1 per cent gentian violet and 10 per cent silver nitrate solutions. A high fever developed and there was clinical evidence of bronchopneumonia on the fourth day following admission. Sulfapyridine in divided doses totaling 22½ gr. in twenty-four hours was given. Marked improvement in the patient's condition was noted and the medication was discontinued at the end of five days. The symptoms recurred three days later and sulfapyridine was again given. Immediate improvement in the child's condition followed and the patient was discharged on the twenty-first day.

chlorides. This usually takes place within twenty-four to forty-eight hours following the accident. Davidson[12,13] found a hypoproteinemia. Harkins[14,15] states that the cells normally contain less chloride than plasma and since in burns the cells are increased, this would explain the finding of low blood chlorides on the basis of the hematocrit changes alone, but would not account for the difference in the results on blood chlorides reported by Davidson[12] and McIver.[16] It has been shown in a detailed study[17] of a group of children suffering from severe burns that early treatment will in many cases prevent these changes, or quickly reëstablish the normal condition of the blood. Again the value of early treatment is indicated.

Certain metabolic changes complicate the more severe burns, as evidenced by early shock, delayed shock, sepsis and exhaustion. In addition, certain pathologic processes may develop, the more serious being pneumonia, nephritis, and gastroenteritis. The use of sulfapyridine in the treatment of pneumonia[18] and certain types of sepsis complicating serious burns has proved of benefit. Six cases have been treated to date by this form of therapy, with no deaths. No symptoms or clinical manifestations have developed in the course of treatment that contraindicate the use of this drug. In three of the six cases, the area involved approximated 40 to 45 per cent of the body surface. One child, seventeen months of age, had bronchopneumonia, and two showed clinical evidence of septicemia. This limited experience leads us to believe that the drug should prove of value in dealing with these types of complications. We do not advocate dependence on this form of therapy alone. The results, although encouraging, are not conclusive. With the use of sulfapyridine, there has been a decided lowering of the temperature (Figs. 2 and 3) in some cases by crisis. There was also improvement in the clinical picture, especially noticeable in chest lesions. The drug has not been prescribed as a prophylactic measure, but in selected cases it should prove a valuable adjunct in the treatment.

SHOCK AND TOXEMIA

The emergency treatment rendered the patient with a burn of minor extent deals mainly with the care of the local lesion. Shock as a complication is not important with this type of burn.

The diffuse burn requires hospitalization for adequate and safe treatment. It is important because of the early complications, the most serious of which is shock. Many lives are doubtless sacrificed as a result of the omission of this principle. From our own experience, and that of others, the incidence of infection is greatly minimized by proper early surgical care of the burn. The early surgical care, followed by the use of tannic acid[3] or gentian violet,[19] also minimizes the tendency to subsequent shock. Pain is reduced after the initial application of these agents, thereby diminishing the incidence of this complication. The extent of the burn bears some relationship to shock, but is not to be relied upon, as we have seen it occur in comparatively slight burns.

The initial shock associated with burns may be entirely due to pain, and also to the extent of the burn. This complication may be of a transitory character and not demonstrable when the patient is first seen by the physician, especially if there has been a lapse of time between the accident and his arrival. This primary type of shock is of neurogenic origin and is manifested by a fall in the blood pressure, a subnormal temperature, increased pulse rate, reduced pulse pressure, and occasionally by cold and clammy extremities.

The patient on admission to the hospital should be given sedation to relieve pain, codeine for children and morphine for adults. The patient should then be transferred in a sterile sheet to a warm first aid or operating room, where dry heat can be applied. The latter is best supplied by an electric blanket. When recovery from the initial shock is apparent, the burn

wound is debrided and given the necessary surgical treatment. This is supplemented by general measures such as intravenous saline and glucose solutions, and early blood transfusions. Saline and glucose temporarily raise the blood pressure and may be given to fortify the patient until blood is available. The temporary action of these agents is due to the rapid elimination by the kidneys; blood, on the other hand, prevents this because of its protein content. Of the blood, the serum alone is vital to this action.[20] In the blood bank there is available blood serum for immediate use in the severe burn case.

Underhill, Kapsinow and Fisk[21] maintain that following a burn, the permeability of the capillaries is in one direction only, namely, from the capillaries to the tissues. If saline or glucose only are available, the additional giving of adrenal cortex hormone may have some merit as the latter is supposed to restore and maintain capillary tone. The clinical experiences of Wilson, Rowley and Gray,[22] 1936, although limited, should be given careful consideration as regards the use of an extract of suprarenal cortex.

Blood concentration is a common accompaniment of a severe burn followed by an anemia, which is due to the loss of fluid at the site of the burn, poor nutrition and internal destruction of the blood. The cause of shock associated with the diffuse burn is still questionable, as is emphasized when one notes the conflicting opinions set forth.[4] Likewise, the cause of the toxemia associated with the diffuse burn may be questioned. Whether this is due to the absorption of chemical toxins from the site of the burn, or due to bacterial toxins, has not been proved. Further research may solve this problem.

LOCAL TREATMENT

1. *Preparation of the Involved Skin Areas.* The importance of thorough cleansing, combined with débridement of the involved skin areas, cannot be too strongly emphasized. This includes the removal of all foreign material and necrotic tissue, the opening of blebs and blisters, and the removal of the loose skin, together with gentle but complete cleansing of the involved surfaces with saline and boric acid solutions. The use of green soap and solvents, such as ether and alcohol, may be necessary. In most instances the proper preparation of the burned area may be successfully carried out with little pain by the use of sedatives, such as codeine in the case of young children and morphine in older individuals. The use of light anesthesia is justified if any vigorous measures are required to prepare the involved areas.

2. *Tannic Acid.* The use of the freshly prepared aqueous solution of tannic acid in 5 per cent strength as a coagulant of the protein on the surface of a burned area, has stood the test of time. The application by spraying has been successful and is still popular. The use of prepared jellies or pastes of 5 per cent or 10 per cent tannic acid strength has been satisfactory, especially in the treatment of burns of the face, and when the freshly prepared solution is not available.

3. *Tannic Acid and Silver Nitrate.* The technique proposed by Bettman[23,24] combines the use of 10 per cent silver nitrate and 5 per cent tannic acid solutions. The tannic acid is applied either as a spray or in jelly form, followed shortly by the application of the silver nitrate solution. The claims for this technique, as stated by Bettman, have been substantiated in most instances, and we believe that this adjunct to the original tannic acid treatment has proved of distinct value.

4. *Gentian Violet.* Gentian violet in 1 per cent aqueous solution as advocated by Aldrich[19] can be conveniently combined with tannic acid. It is our practice to use the dye in burns showing evidence of infection when first seen, or in cases of more than forty-eight hours' duration when first treated. Burns involving the perineum, the hands and feet, and deep burns encircling the extremities or in the region of joints should be treated with gentian violet

solution. The dye may also be combined in the treatment, following the use of tannic acid, where there is separation and evidence of infection about the edges of the coagulum.

5. Gentian Violet and Silver Nitrate. Following the experience with silver nitrate combined with tannic acid, a similar technique was used substituting gentian violet for tannic acid. The results in a small series of cases were satisfactory and provided the basis for a published report.[25] This combination has to some extent offset certain disadvantages of the gentian violet solution when used alone. A firmer coagulum is produced, drying is more rapid, and the disagreeable staining properties are somewhat limited. In addition, the antiseptic properties of the gentian violet solution appear to be increased by the combination with silver nitrate.

The burn resulting from acid or an alkali should always be thoroughly washed with water before applying the neutralizing agent. Sodium bicarbonate solution is effective in the case of the acid burn, and acetic acid may be used as the neutralizing agent for the alkali burn.[26]

LATER TREATMENT

Following the local application of one or a combination of the various preparations mentioned, and the formation of a protective covering, the treatment of the lesion resolves for the most part into close observation and the early detection of any unfavorable symptoms. It is convenient to treat the patient during this stage under the so-called "burn tent" and without dressings or covering of the involved areas other than provided by the coagulum. The temperature within the tent should be maintained at 85 to 90°F. Since these patients have a lowered resistance to infection, respiratory complications may follow extreme changes in temperature.

The problem of local infection is always to be borne in mind, and if it does develop, the subsequent treatment must be based on the patient's reaction to this infection. The removal of the coagulum may be necessary if the evidence of absorption increases to an alarming extent. The coagulum should be left intact, if possible, for a period of ten days or two weeks. Davidson[3] pointed out the dangers of disturbing the crust or applying softening agents in the first week of treatment, as he observed that a number of the patients had a recurrence of toxemia when the crusts were softened by wet compresses. If it is deemed necessary to remove the coagulum in cases of extreme infection, this can be performed under light general anesthesia.

The preparation of the denuded surface following the removal of the coagulum in deep burns may necessitate exposing the exuberant granulations to the air or to a heat lamp for purposes of retarding the growth by shrinkage and dehydration. Where extensive infection is present, the application of compresses saturated with half strength Dakin's solution may be used. Boric acid or normal saline solutions are applied if the infection is of lesser degree. The removal of exudate and small portions of coagulum can be further hastened by immersing the part in the brine bath. It should be noted that this latter procedure may be exhausting to the weakened patient. The brine bath treatment, in the early stages of the extensive burn case, as advocated by Blair and Brown,[27] has not been used.

Early skin grafting is desirable in all cases requiring the transfer of epithelium to the denuded surfaces. In many cases this is a life saving measure, and often through early grafting extensive scarring and deformities can be prevented. To allow a large granulating surface resulting from a burn to remain as a definite hazard to the recovery of the patient is gross negligence on the part of the surgical attendant. In our experience the deep pinch graft has proved successful in a large number of cases where there was extensive involvement of body surfaces. The advantages are (1) the success obtained with this

type of grafting in the presence of considerable infection, (2) the covering of areas of considerable extent, which is possible with little shock to the patient when carried out in short operative stages. The proponents of the Thiersch and split thickness grafts have much in their favor, and undoubtedly this type of grafting has been very satisfactory in trained hands. The treatment of contractures and disfiguring scars is a problem for leisurely consideration and does not fall in the scope of this discussion.

Many preparations have been cited as possessing the property of stimulating regeneration of epithelium in the case of extensive burns. Our experience with a number of such preparations leads us to believe that for the most part such forms of therapy are of minor importance in the treatment of the more severe types of burns. However, scarlet red gauze, prepared according to the formula given by Bettman,[23] definitely aids in the healing of small granulating surfaces, and provides a satisfactory dressing in the healing stages following skin grafting of more extensive areas. During the stages of healing and the grafting of extensive granulating areas, small blood transfusions are of value in combating the state of exhaustion complicating these cases.

The importance of close attention by the surgeon during the treatment of the healing stage must again be emphasized. The prevalence of disabling deformities as the result of negligence in the care of such lesions has been the subject of a previous article.[28] Attention to maintaining proper position during the healing stage can prevent, in a measure, these serious complications, and may mean the difference between a satisfactory outcome and a condition which cannot be sufficiently improved by corrective treatment. Teamwork is necessary to achieve a satisfactory result in the treatment of severe burns. The attending and house staffs, together with the nursing personnel, must coöperate in providing the proper care, while attention to all details of treatment must be closely adhered to.

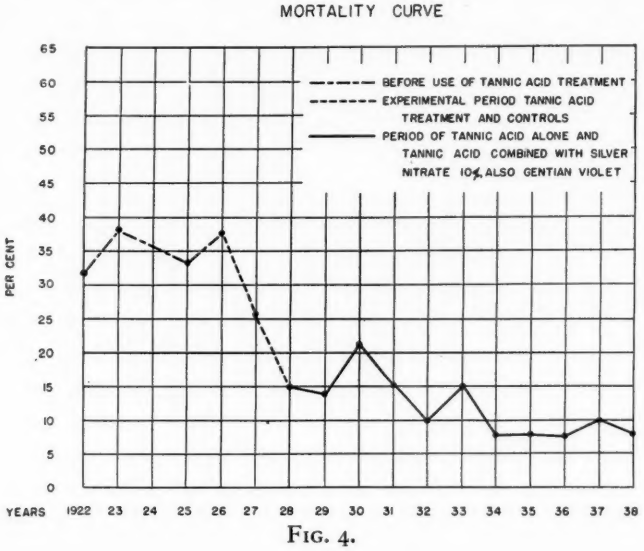

FIG. 4.

RESULTS OF TREATMENT

The treatment as outlined is not claimed to approach the ultimate goal in caring for severe burns. Much remains to be accomplished in this respect, but adherence to the principles herein advocated will give satisfactory results in view of the present knowledge of the subject.

The advantages of the tannic acid treatment are as follows:

1. The coagulum produced by tannic acid minimizes toxemia resulting from absorption from the burned area.[3,29] Considerable doubt has been thrown on the theory of toxic absorption in relation to burns. Davidson believed that the theory did not satisfactorily explain all the symptoms in severe cases of diffuse burns, but there was convincing evidence that absorption of a toxic substance, formed at the site of a burn, produced certain constitutional reactions. The work of Bardeen[30] supports this idea. In spite of attempts to discredit this theory, many workers in the field still adhere to the principle of toxic absorption.[1,31,32,33]

2. It lessens the loss of body fluids from the burned area. Although it appears that the loss of body fluid from the burned area is not so great as previously thought, there is undoubtedly a considerable amount of "weeping," which is prevented by the forming of a coagulum.

3. The coagulum over the burned surface acts as a protection against infection. The tannic acid coagulum provides a physical barrier to the entrance of bacteria. Also, close adherence to the basic principles in the care of this type of surgical lesion prevents to a considerable degree the development of infection.

4. It lessens pain, thereby minimizing shock. Clinical observation has given conclusive evidence in support of this statement.

5. The treatment combined with the use of the light tent simplifies the care of burns. This claim needs no discussion.

6. The protective layer of coagulated protein forms a scaffold for the growth of the young epithelial cells over the denuded surface.

7. This method of treatment, supplemented by supportive measures, has materially reduced the mortality in cases of diffuse burns. The mortality statistics for a period of years preceding and following the introduction of the tannic acid treatment at the Children's Hospital of Michigan are graphically shown. (Fig. 4.) The average mortality since the introduction of this form of treatment is 11.5 per cent. During the years 1932–1938 the mortality has averaged approximately 8 per cent. It is recognized that the statistics, for the years referred to, reflect improvement not only in the local treatment, but also in all supportive measures used to improve the general condition of patients suffering from severe diffuse burns.

SUMMARY

1. The severe burn case carries a responsibility not only for the attending surgeon, but for all individuals participating in the treatment. Close attention to details of therapy is essential.

2. The burn must be treated as a surgical wound preliminary to the application of the therapeutic agent.

3. Shock is an early complication and must be dealt with by the early administration of sedatives, heat to the body, and parenteral fluids, in addition to blood transfusions.

4. The local agent used may depend upon the type of burn and the experience of the attending surgeon.

5. Sulfapyridine has proved of value in a limited number of cases with sepsis and upper respiratory complications.

6. The acid or alkali burn should be thoroughly washed with water before applying the neutralizing agent.

7. Attention to the position of the patient is important to prevent contractures and deformities, and to obtain the best functional result.

8. It should be emphasized that attention to the nutrition of the patient is important and may be supplemented by frequent small blood transfusions to combat the secondary anemia, which is associated with exhaustion.

9. Early skin grafting minimizes loss of fluid from the burned area. The effects of infection are also reduced, thereby limiting scarring and contractures.

10. Physiotherapy may assist in the rehabilitation of the patient and restoration of function.

11. The results of treatment in the severe burn case show a favorable lowering of mortality by the use of modern therapy.

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MODERN ASPECTS OF MANAGEMENT OF CRANIOCEREBRAL INJURY

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IN spite of nation-wide organized efforts to prevent accidents in our country, the number of injuries and deaths by this means still remains alarmingly high. Although accurate statistics are not yet available for the whole nation, it is estimated that at least 100,000 cases of craniocerebral injury are cared for each year. Although probably most of these are being cared for in the 2,030 hospitals which have been approved for surgery by the American College of Surgeons, undoubtedly many are being treated in smaller hospitals and some at home by general practitioners.

Statistical studies of large series of cases are of definite value and help in the general progress being made in management. But instead of attempting to report our experiences from a study of over 1200 cases of craniocerebral injuries treated in this hospital, we have planned to limit the scope of this paper to enumerating some practical points in management with special reference to some of its newer aspects. We hope that this may stimulate those who are not specialists to acquire for themselves from the literature a broader working knowledge, which should make for more satisfaction in the care of these cases and bring about better immediate and end results.

As evidence of an increasing general interest in this problem, over 700 articles were listed in the Cumulative Index of the American Medical Association for the last three years. An increasing number were experimental work dealing with the chemical and physiologic aspects.

We shall not concern ourselves here with the average case, labelled as concussion, in which little or no serious brain damage has occurred and where usually a good organic recovery results. But we are extremely interested in the 20 per cent that have in the past been called contusions, lacerations and hemorrhage. And we would like to see a further reduction in the death rate which averages from 10 to 18 per cent. There are three types in this latter fatal group, which challenges us to improved methods of care: (1) those patients who are dying from localized removable clots or encysted fluid which are not being diagnosed and operated upon early enough; (2) those dying from anoxia because unfavorable cellular changes are permitted to develop from a recoverable to a hopeless state through misconceptions or ignorance of cellular physiology; and (3) those dying from the secondary effects of medullary and vasomotor shock which might be prevented if treated promptly and effectively.

A subject worthy of more emphasis than is possible here is a review of the anatomy and physiology of the brain and its circulation. One can better anticipate probable results of fractures of the skull if one remembers such points as: (1) the thinner more brittle inner table of the vault; (2) the closely adherent, rigid-walled, easily torn, blood sinuses at the base; (3) the half bony and half dural canal for the lower part of the middle meningeal artery just after it enters the skull through the foramen spinosum, as it is here that the artery is commonly torn across in skull fractures; (4) that venous stasis is an easily produced complication of brain swelling because of the roundabout, antigravity flow in veins and sinuses; (5) that destruction of brain cells is made easier because the arterial blood is carried by end vessels with little or no collateral circulation; and (6) that the normal circulation of the cerebrospinal fluid is easily interfered with because of

limited reserve space and the easily obstructed connecting aqueduct of Sylvius and foramina of Majendi and Luschka.

Physiopathologic facts also to be borne in mind are: (1) that aside from direct damage to, or cutting off of, the vital centers by tissue destruction, the most important disturbance that results from cerebral trauma is that affecting the circulation to and from the brain cells; (2) that shock, swelling of tissue, anemia, hyperthermia and depression by hypnotic and sedative drugs are apt to set up vicious cycles which may result in one or more forms of anoxia of sufficient severity frequently to produce characteristic destruction of brain tissue; (3) that brain cells are much more vulnerable to oxygen deprivation than other body cells and are destroyed if the oxygen is completely excluded for five to ten minutes; and (4) that apparently there is no regeneration of the important cells thus destroyed.

Fracture of the skull still seems to be held in the mind of the average layman, and particularly in a jury, as *the* important index of seriousness of head injuries. It has been brought out in many papers, apparently without enough general knowledge as yet, that the skull fracture of itself is important only in the following: (1) as an indication that the trauma has been at least fairly severe; (2) when the fracture is compound and thereby may have permitted foreign material to penetrate to the brain; (3) when the fracture has gone more or less horizontally across the lower part of the temporal bone and severed the middle meningeal artery as it lies in the canal which is part bone and part dura, thus resulting in the rapidly forming and potentially fatal extradural clot; (4) when the fracture has torn across a basal blood sinus, with its usual resulting fatal hemorrhage; (5) when the fracture extends across the petrous bone or the ethmoids, or into the frontal air cells, resulting in cerebrospinal rhinorrhea, with its risk of subsequent meningitis; and (6) if the fracture is depressed. Otherwise the type, location and results of the brain damage are the important factors.

In earlier years the chief emphasis in management of brain trauma was the control of so called "compression." Surgical intervention was common. Death rates were high. During the last two or three decades more conservatism has been the rule and the non-surgical decompression of edema has been accomplished by lumbar punctures and dehydration. The amount of operating has been reduced. The mortality rates have been decidedly less than before.

But of late it has become apparent to many that still further improvements in results are possible. As they have in the past, so they will in the future depend upon the scientific advance in physiology and chemistry.

The destructive effect of cerebral trauma upon brain tissue and cerebral circulation has long been known and throughout the years considerable valuable experimental work has been done upon the various problems such as edema, anemia and hemorrhage. There has been accumulating more and more valuable information from experiments in the field of cellular physiology using biochemical and electrical methods. This is forcing a change in many of our old conceptions and is bringing about a gradual transition in some of the principles of management, with apparent benefit.

We shall not attempt to give a comprehensive list of the many contributions, but will mention a few which are pointing the way to further progress. After his excellent monograph with Rand[1–6] on cell changes from fatal cerebral trauma, Courville revived interest in the problem of cerebral anoxia.[7,8] Since then much work has been done by a number of investigators on the effects upon brain cells of oxygen deprivation, sedative and hypnotic drugs with results which compare with his findings.

Schreiber and Gates[9] and later Schreiber[10] reported studies made upon over 500 children, where apnea at the time of birth had been present in over 70 per cent of the infants. The study related the analgesics

given to the mothers at delivery, the apnea of the infants at birth, the later development of signs and symptoms of anoxia, and the subsequent objective evidences of cellular destruction.

Hartman[11] summarized the important data upon cerebral anoxia. The combined material in this and his previous reports, alone[12] and with Major[13] convincingly show that destructive cell changes, conforming to the pattern characteristic of anoxia, can occur from hyperthermia, narcotics and hypnotics, acute alcoholism, cerebral injury, and acute shock. Cell deprivation of oxygen seems to be common to all these conditions and it is reasonable to conclude that it is the important factor.

The effect of anemia upon brain cells was restudied by Gildea and Cobb[14] on cats. They corroborated the previous findings and concluded that ten minutes of complete cutting off of arterial blood is sufficient to produce permanent cellular destruction characteristic of anoxia. The earlier teachings had given the limit as five minutes.

The problem of anoxia is, of course, complex. Cellular deprivation of oxygen is intimately related to tissue and blood oxygen tension, sugar and other chemical constituents in the blood, and is definitely affected by sedative and hypnotic drugs and hyperthermia.

Gerard,[15] in an excellent summary of anoxia and neural metabolism, stated that the brain is thirty times as sensitive to oxygen deprivation as muscle or nerve tissue and that oxygen tension controls the utilization of sugar. Gellhorn, Ingraham, and Maldavsky[16] studied the influence of hypoglycemia on the sensitivity of the central nervous system to oxygen want. They found that the oxidative processes of the cells are diminished by the hypoglycemic state. Cheyne-Stokes respiration, present during experiments with low sugar content and reduced oxygen, could be abolished by increasing the blood sugar towards normal. McClure, Hartman, Schnedorf, and Schilling[25] found clinically and experimentally that the barbiturates, morphine and avertin produced a sharp decrease in oxygen saturation of the blood and oxygen utilization by brain tissues. Unfortunately in trying to interpret pathologic findings no one can be certain which of the post-mortem cellular changes were present before and were a part of the cause of death, and which changes developed during the agonal stages which just precede death.

The mechanism of post-traumatic brain swelling and edema is a problem about which there is still no unanimity of opinion in spite of much experimental work. Because of the inherent difficulties, no one has yet been able definitely to prove the exact relationships of the various factors. Pilcher,[17] from a study of sixty experimentally traumatized dogs' brains, was unable to find conclusive evidence of edema and explained the increased pressure by disturbances of the blood and cerebrospinal circulations. Shapiro and Jackson[18] studied brains of fatal traumatic cases and by various methods of dehydration found that the subarachnoid fluid was not increased, but decreased, the brain swollen but not edematous. Part of the swelling was thought to be by ventricular distention and part by scattered hemorrhages. Both of these articles[17,18] contain excellent bibliographies.

As a result of the divergent views on this subject, therapy now varies between two extremes, on the one hand marked dehydration as advocated by Fay[19] and lumbar punctures advised by Munro[20]—and on the other, the extreme conservatism of Sachs[21] and Dandy.[22]

Other factors which cause an increase in cerebrospinal fluid pressure are blood, as shown by Bagley[23] and Parker and Lehman.[24] Schnedorf,[25] in experiments on dogs, found an increase in cerebrospinal fluid pressure and proteins, from simple cisternal withdrawal and immediate replacement of the fluid. Oxygen given intranasally lessened these rises.

The factor of hemorrhage also is not completely understood. In the severely injured or fatal cases it is not known how

much of the bleeding is the direct result of the trauma and how much is due to disturbed physiologic functions incidental to the treatment and terminal states. Nor is it definitely known whether or not spinal drainages are entirely beneficial in the presence of subarachnoid bleeding. A number of informative articles on this subject have appeared during late years, to which the reader is referred. Hemorrhage is of course by far the most serious complication of cerebral trauma and offers the greatest challenge to us all to find ways to lessen or control in the early stages. Promptly localized epidural and subdural hematomata often can be successfully treated surgically if there is not too much brain damage in addition.

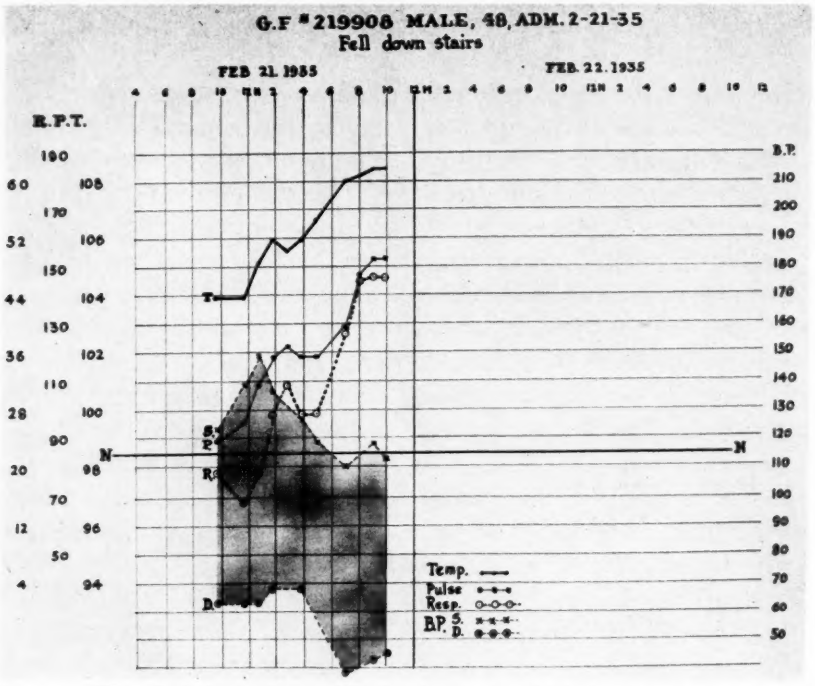

Chart 1. The vital signs of a rapidly fatal case, in which death occurred due to a basal hemorrhage.

Another important problem about which there is as yet no general agreement, is the accurate definition of the diagnostic terms concussion and contusion. Miller,[26] in an excellent summary of the theories of concussion, defined this as a transient state with immediate unconsciousness and with spontaneous recovery without sequelae. He reported cases of rapid death, apparently belonging to the concussion group, which seemed to be due to paralysis of the respiratory center. Forbes and Wolff[27] concluded from experiments on dogs that the cerebral circulation is in part at least controlled by cerebral vasomotor nerves. Schaller, Tamaki and Newman[28] reported eleven fatal cases and experimental data on albino rats all of which had died of petechial hemorrhages which were judged to have been caused by reflex vasomotor phenomena, and not by the direct action of the trauma.

These and other experiments on the vasomotor control of circulation may ultimately give us a more scientific explanation of the cases which show post-mortem diffuse punctate hemorrhages, apparently out of proportion to the severity of trauma. And this may force us to add another group in our clinical classification of cases.

From the above review, it is apparent that the results of brain trauma still present many unsolved problems,[29] which

challenge the best efforts of clinicians and scientists.

Regarding diagnosis, until some more satisfactory classification is available, we shall continue to group our cases as concussion, contusion and laceration. Hemorrhage may accompany any of these three. With the latter two the brain may become swollen and engorged, depending upon the many variable factors mentioned above. Before one can safely evaluate a recently injured patient, one must insist upon obtaining full details of the mechanism and severity of trauma, the duration of primary unconsciousness. Also it must be determined early if there is probably a rapidly developing hemorrhage or if there is any condition requiring surgical interference so that effective appropriate treatment may be made available without delay, even though this may mean a careful transfer by ambulance to the nearest suitable hospital.

There are two sets of signs and symptoms to interpret, the medullary and the cerebral. In our teaching we spend considerable time emphasizing the medullary signs. Chart I illustrates a rapidly fatal case due to basal hemorrhage. Chart II is a rough diagram we use to show the average course in fatal cases. It will be seen that the temperature and respirations usually change a little more promptly than the pulse and blood pressure. As has been pointed out by Browder and Meyers,[30] death occurs in some cases without showing these characteristic signs, but this represents the usual case. The important point to remember is, that if measures to relieve developing medullary compression are to be instituted, they must be done before the third stage develops with its stertorous, irregular or Cheyne-Stokes respiration, rapid, progressively weakening pulse and sharply rising temperature. These are evidences of beginning medullary failure and the resultant cerebral anoxia which in a few minutes will bring about hopeless or fatal destruction of cells. One must be on the alert, if anticipating possible middle meningeal bleeding, not to be lulled into a sense of security by the apparently favorable, full, bounding, slow pulse and the

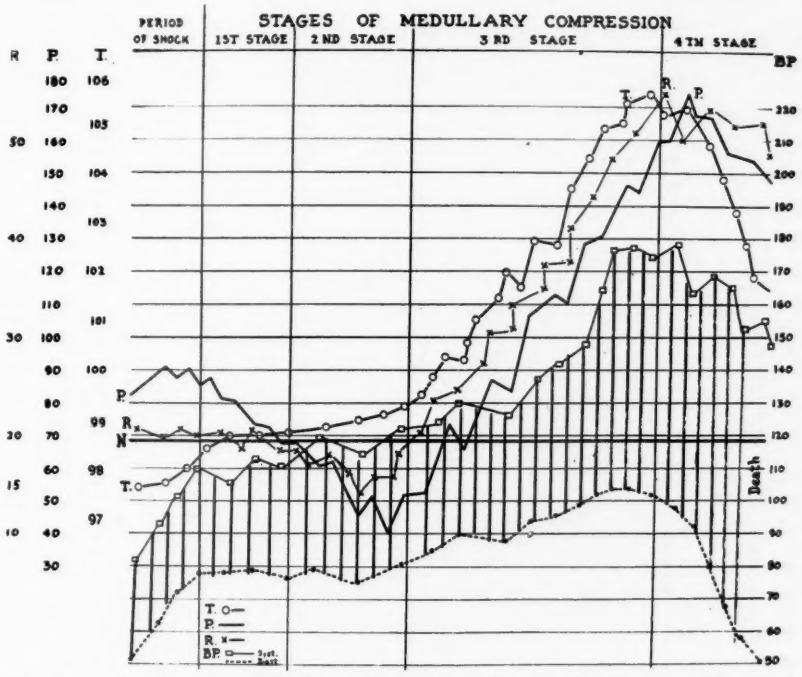

Chart II. A diagrammatic chart of averages of many fatal cases. The vital signs are shown during the period of shock and then traced through the four stages of medullary compression. Chronologically, the third and fourth stages may be much longer than shown here.

slowed, deeper respirations of the fateful second stage. Here usually the temperature gives a helpful clue, and one is further informed by the cerebral signs of progressively deepening stupor (after the lucid interval of two to six hours), and the localizing sign of first constricting and soon dilating pupil on the side of hemorrhage. The muscle tone of the face and upper extremity and deep tendon reflexes on the opposite side complete the diagnosis. It is by frequent comparison of these various findings that one can best judge the course.

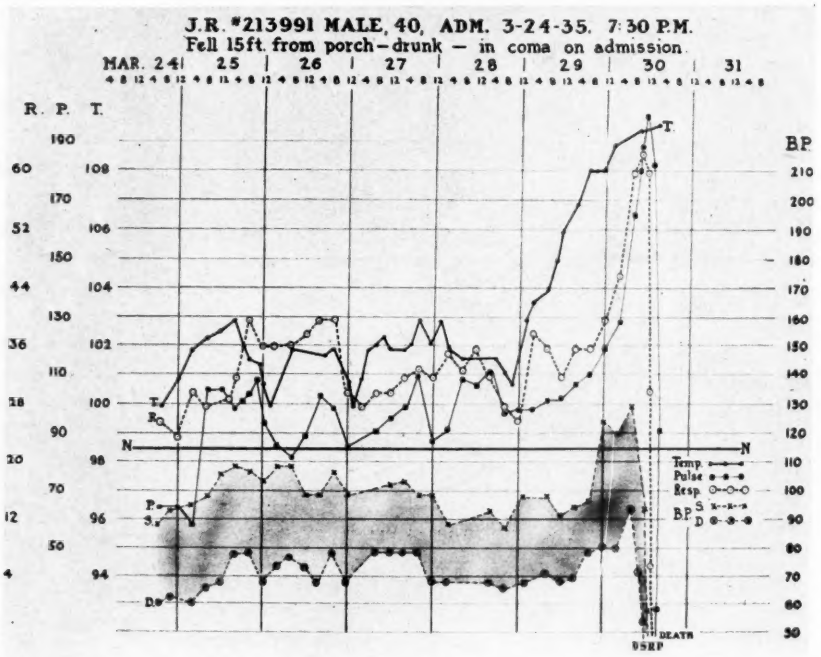

CHART III. An illustrative case of delayed death. In such cases the pathologic changes are mainly microscopic. Evidences of swelling, edema and gross hemorrhage may be absent.

Chart III illustrates a common type of fatal case. Death occurs after several days, and often the pathologic findings after death do not seem severe enough to be incompatible with life. It is with this group of cases that we must strive for better results. Such conditions as toxic dehydration and hypoglycemia must be guarded against. Repeated arterial blood oxygen determinations should be done. Depression by drugs must be avoided. Morphine, especially, is undesirable because of its depressant action on the medullary centers and because it thus masks important diagnostic signs.

During the first few hours in a potentially serious case, frequent checks of vital and neurologic signs should be recorded by competent observers. Nurses can be taught to render valuable data if properly trained. During the examination one must remember the possible complicating presence of an accompanying injury to the chest or an intra-abdominal viscus, with its resultant profound shock. Gentleness of handling and avoidance of unnecessary exposure of the patient's body are important precautions. Spurling and Bradford[31] have given an excellent outline of neurologic diagnosis.

Management of the different types of cases was outlined in our previous communications.[32,33] A complete report on over 1200 cases is planned in the near future. We would stress again the importance of adequate treatment of shock, careful, thorough and prompt debridement of wounds, and the taking of *x*-rays when and if shock is past. All unconscious patients should be hospitalized at least one or two

days to be assured against slowly developing hemorrhage.

We institute oxygen therapy early in cases with persisting unconsciousness, particularly if the arterial blood oxygen is at all low. The normal blood oxygen saturation is 95 per cent. With levels below 85 per cent, the development of anoxia is speeded by such factors as hyperthermia, hypoglycemia, acute alcoholism, sedation by drugs and the progressive swelling, edema and hemorrhage of trauma. A preliminary communication regarding oxygen therapy in some of our cases has been made.[34] A more complete report awaits more experience. Measures advocated are to keep the blood oxygen and sugar levels as near to normal as possible to support the blood pressure at time of shock, and to avoid use of sedative and hypnotic drugs if at all possible. With the Hartman oxygen apparatus it is possible to keep the patient in as high oxygen atmosphere as desired (80 per cent to 100 per cent). It should be remembered that sucrose, while it is an effective dehydrating agent, may be toxic to some kidneys and is not utilized as nourishment by the tissues, an important point to remember if hypoglycemia exists. We combine sucrose and glucose according to conditions, and keep careful track of blood sugar during dehydration and of the urine when using sucrose.

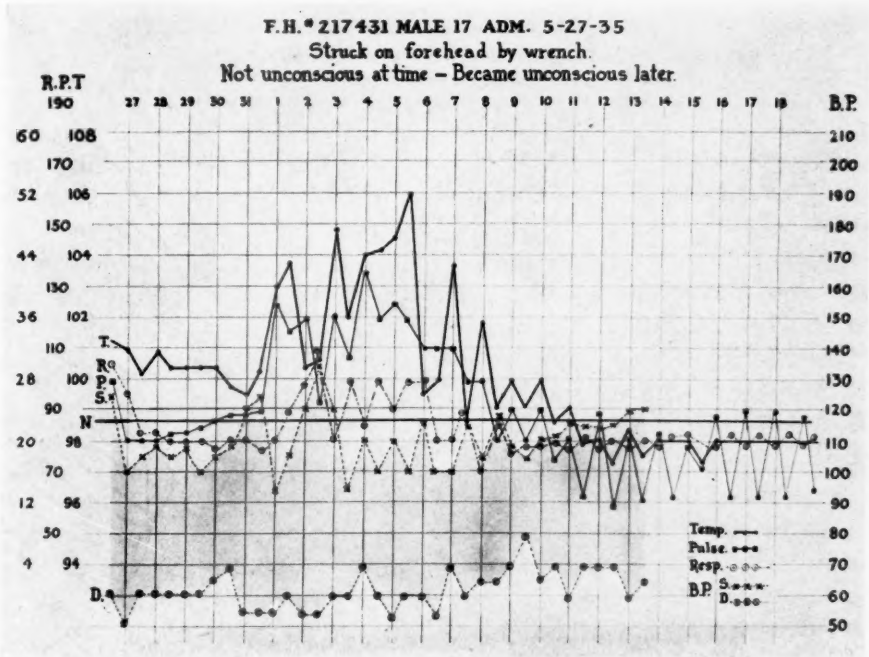

Chart iv. A case of delayed edema. Markedly relieved by strenuous dehydration régime of glucose, sucrose and lumbar punctures.

Lumbar punctures give valuable data regarding intraspinal pressure and indicate the presence and amount of bleeding. They usually are not necessary or desirable until the stage of acute hemorrhage is past, but may then be helpful in removing blood from the subarachnoid spaces. They should not be done routinely in every case, but should rather be limited to cases which present generally accepted indications.[20,33,39]

We advocate and apply the principles of dehydration, in cases where edema develops as a complicating factor, but in our experience these cases occur relatively infrequently. Chart iv is of an illustrative case of effective results of repeated periodic use of glucose, sucrose and lumbar punctures. We have failed to see benefit from this procedure in cases where lacerations and hemorrhage were the main lesions. Our experience leads us to agree with Browder and Meyers[47] who state that intracranial tension is not the basic problem in the

management of craniocerebral trauma. We would also warn against the indiscriminate use of hypertonics.

In comatose or moribund patients, where the respirations are stertorous and pulmonary and laryngeal edema are beginning, pneumonia may be avoided if the foot of the bed is elevated and the face turned sideways and below the level of the trachea as advocated by Coleman.[35] In cases of persistent cerebrospinal drainage from ear or nose, in addition to operative closure of the defect in the dura, we administer sulfanilamide early as a preventative against meningitis. We have had some cases where this treatment apparently did prevent such a complication. For further details on therapy, the reader is referred to such articles as those of Munro,[20,36,37,38] Swift,[40,41] Craig,[42] Ney,[43] Battle,[44] Jackson, Dickerson and Gunther[45] and Mock.[46]

The surgical aspects of the problem are too extensive and specialized to be included here. Surgery is indicated in: (1) all compound fractures; (2) extradural hemorrhage; (3) depressed fractures, which should be operated on immediately if compound or if signs of compression are present, otherwise at a later date; (4) fractures resulting in cerebrospinal rhinorrhea; and (5) as a decompressive measure in a few cases where medical means have failed to prevent dangerous compression. (6) Subdural hemorrhages and hydroma can often be diagnosed only after exploratory trephines are made.

The end results, complications, sequelae and prognosis are problems which will be discussed fully in a subsequent communication. Suffice it to say, that although the immediate and end results have seemed to improve slightly from year to year, we should strive to save more patients from preventable deaths, to overcome where possible, in the early stages, the unfavorable processes which may result in slow death or in persistent unfavorable sequelae or even in permanent mental impairment. Also by attention to the psychic factors, we should try to avoid, where possible, the train of events which, in the predisposed, so often leads to the development of psychoneuroses.

SUMMARY

1. The management of craniocerebral injuries in this country is becoming a problem of increasing importance.

2. Success depends upon a thorough working knowledge of the anatomy, physiology and pathology of the brain and the cellular changes caused by trauma.

3. Although there are still many unsolved problems, new data are accumulating which in time should place management on a more scientific basis with better results.

4. A pathologic process of great importance is the destructive cellular change which results from such conditions as anemia, hyperthermia, hypoglycemia, tissue swelling, shock, metabolic depression by hypnotic or sedative drugs and acute alcoholic intoxication.

5. Oxygen therapy, from our experience thus far, promptly increases diminished oxygen saturation in the blood. If used early enough and in sufficient concentration, 80 to 100 per cent, it may help to prevent the development of dangerous anoxia, particularly if the blood pressure is supported in shock.

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TRAUMATIC INJURIES TO THE EYE AND ITS ADNEXA

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THE scope of this subject is so vast that consideration of each phase must of necessity be brief. Case reports and statistics have been purposely avoided. The material has been divided into separate headings and each part discussed by stressing the fundamentals from an ophthalmologic point of view, based on experience and observations made on cases in this clinic.

INJURIES TO THE LIDS

Lacerations of the lids are often poorly repaired due to the minuteness of the anatomic structures and a lack of appreciation of the functions of this part of the eye.

Lids may be torn from either the outer or inner canthus and left hanging at one extremity or the other. This is particularly true of the upper lid. A line of tear at first vertical will often follow the retrotarsal fold across the lid. This indicates that the levator muscle has been disrupted and must first be sewed back to the posterior border before considering the orbicularis muscle and cutaneous structures. Adherence to this procedure will often prevent a permanent ptosis. The function of the lid appears lost at first but will gradually return.

The vertical portion of the laceration, as well as all other vertical tears or cuts wherever placed along the lid margin, must be closed, as Wheeler has proposed, by the "halving" method taken from the principles or carpentry. The tarsal plate must first be brought into exact alignment and coaptation. Sufficient paring of jagged edges to accomplish this may be done without fear of too much loss of substance. The orbicularis fibers and cutaneous structures are then lapped over this tarsal plate closure, and reinforced by mattress sutures through all structures. This procedure will prevent many unsightly notches or colobomata which later require correction.

Injuries to the lower lid which involve the inner canthal region are very difficult to repair. Two conditions are likely to occur: (1) severing of the canaliculus; (2) retraction of the lower lid due to lack of proper coaptation of the laceration at this point.

A reunion of the canaliculus is an extremely difficult but not impossible task. This clinic has been very fortunate in accomplishing it in several cases. The repair is made by passing a number one Bowman probe through both the punctum and the portion of the canaliculus in the severed lid, then through that portion still attached to the lacrimal sac if it can be located. This holds the sectioned ends together until the lid repair is completed. Attempts have been made to do the so-called retrograde bouginage from the open tear sac but with very little success.

In order to avoid retraction of the lower lid due to poor coaptation of inner canthal tear, the tarsal plate must be reunited to the inferior portion of the tarsal ligament. Skin suturing alone will not suffice as relaxation will result.

In regard to skin closures in lacerations about the eye, emergency sutures are frequently very poorly applied. This probably happens because of insufficient training or instruction during the internship years. Too large suture material, too widely and too deeply placed sutures resulting in poor coaptation, and inadequately pared edges are the errors most often seen. Such work should be done over, if found early. Wounds about the eye, if deep, should be closed by suturing the subcutaneous tissue

with triple o catgut. The skin closure should be done with interrupted dermal sutures at close intervals and including the smallest amount of skin possible. Drains should be avoided.

INJURIES TO THE EXTRAOCULAR MUSCLES

Injuries to these muscles may be caused by objects penetrating the orbit or by fractures involving the apex. When such injuries occur, the function of the extraocular muscles should always be tested. Injury to the external rectus and to the inferior rectus has been encountered in separate cases. The torn bellies of these muscles are difficult to find, but there is much more difficulty if the wound is allowed to heal and the attempt made later.

The third, fourth, and sixth cranial nerves enter the orbit at the apex and may be injured by a fracture of that region. Paralytic muscles have resulted, causing compensation difficulties from a visual function standpoint. Consequently it is very important to repair muscles if possible at the time of the original injury. Paralyzed muscles resulting from nerve injury may receive plastic support from adjacent functioning muscles, giving sufficient aid to avoid obnoxious diplopia and loss of binocular vision. Paresis of a muscle has occurred from a simple blow to the globe and orbit. Recovery has taken place in one to three months in all such cases observed.

CONTUSIONS OF THE GLOBE

Since vision may be impaired by the quick snap of a rubber band as well as by a heavy pugilistic blow, all such injuries involving the globe should receive careful consideration. Intraocular hemorrhage usually occurs, but need not be present. It is necessary to recall that a contusion of the eyeball may produce any one or more of the following conditions: traumatic iritis with segmental paresis, dislocation of the lens, early cataractous changes, contusion of the retina at the point of keenest vision, tears of the retina with resulting separation from the choroid, and tears of the retina and choroid without separation. This latter injury occurs most frequently about the optic disc, radiating outward. Invariably such lines of tear manage to cross entirely or partially between the disc and the macula, thus destroying central vision. The reason for this may be explained by the mechanism of a contrecoup blow plus the character of the retina in this region and the position of the macula. All of the conditions mentioned above require absolute bed rest and atropine until satisfactory examination of the eye can be made and the fear of a separated retina or dislocated lens is allayed. The best results in treatment of separated retina, however, have been obtained in the traumatic group.

PERFORATING WOUNDS OF THE GLOBE

Any puncture wound of the eyeball, however small, requires careful investigation and treatment. Some may be overlooked even with the most careful observation. The location of a perforation may be in the sclera, the limbus, or the cornea. Many involve both limbus and cornea.

Small wounds of the cornea are easy to miss without the aid of the slit-lamp. Simple indirect focal light, however, with some magnification before the observer's eye is often adequate. Although fluorescene is preferred, mercurochrome in any of its strengths makes a good stain and aids greatly in defining the extent of the injury. These small wounds are important because they frequently indicate the presence of a foreign body.

The limbus has long been considered a vital spot in injuries to the globe because of trauma to the underlying ciliary body, and because this area is regarded as the danger zone for sympathetic ophthalmia. It may be noted, however, that in the treatment of a great number of industrial cases in this clinic in the past twenty years, no cases of sympathetic ophthalmia

due to trauma of the ciliary body have been encountered.

Perforations of the sclera may be easily

Fig. 1. Poor lid repair.

obscured by conjunctival hemorrhage, but early recognition of these wounds enables one to take proper precautions against detachment of the retina. A careful fundus examination is always necessary. The presence of blood in the vitreous may indicate a perforation or a foreign body. The *x*-ray should be resorted to in all such instances not only to help determine the presence of a foreign body but also to protect the surgeon in case of medicolegal difficulties.

Rupture of the eyeball as a result of a severe contusion is not unusual. The lens has been found nicely extracted and lying under the conjunctiva. Regardless of the cause of injury, many of these wounds heal by first intention after masterful inactivity on the part of both the patient and the surgeon.

Prolapsed iris must always be removed from corneal wounds and should not be tucked back into the anterior chamber. It probably would not remain there and furthermore it may carry infection back with it. Suturing of corneal wounds is practiced by some surgeons but requires skill and special instruments. Unless one is so equipped, less trauma will result by using a conjunctival flap or the closed lids as a splint. A badly injured eye is easily made worse by too much manipulation. One should not be too hasty in advising removal of an eye, for vision of $^{20}/_{30}$ or better has been obtained in what looked like a hopeless eye. Both surgeon and patient should have a few days' leeway to consider such an important step.

Should the removal of the eye become necessary, the surgeon should be governed in his choice of operation by the presence of acute infection or a prolonged low grade chronic inflammatory state. Although traditional ophthalmologic teaching recommends evisceration for the first and enucleation for the second of these conditions, we have used evisceration almost exclusively without extending infection or aggravating the production of sympathetic ophthalmia. There is no question but that the cosmetic results following evisceration with glass or gold ball implant in the sclera are superior to those following enucleation and ball implant into Tenon's capsule. Mucus, which is a great annoyance to patients, often collects on the prosthesis after enucleation while no such condition has been found to follow evisceration. The use of rib cartilage as an autogenous implant was used for a time in this clinic, but it added nothing to the function of the socket and its use has therefore been abandoned.

TRAUMATIC CATARACTS

Injury to the lens occurs frequently with trauma to the globe. The formation of a cataract, if sufficient to cause loss of vision, is compensable in most states, whether it is removed or not. Most industrial organizations are very willing to have everything possible done for such patients. Consequently cataract surgery is performed whenever indicated.

The diagnosis of traumatic cataract is not difficult. Occasionally, however, a medicolegal complication arises where it is necessary to give an opinion as to the type of cataract present. A careful study of the opposite lens should be made for similar markings, whether nuclear, cortical or capsular, in order to rule out congenital abnormalities. It must be remembered that contusion cataracts may arise without a break in the coats of the eye, therefore a

diligent search for capsular scars and associated cortical changes must be made. The capsule may close or be plugged by

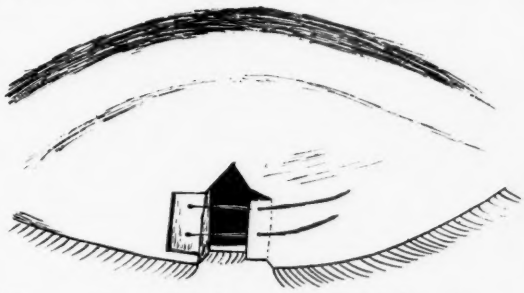

Fig. 2. Wheeler halving operation in lid repair.

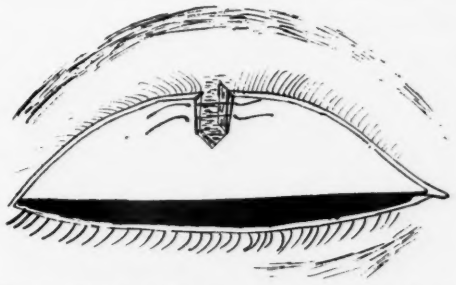

Fig. 3. Placing of sutures in the tarsal plate in the Wheeler operation.

cortical substance so that further entrance of aqueous is blocked and extension of the process in the lens substance stopped. Should this be in an eccentric position, fairly good vision will be maintained for an indefinite time. Here prognosis should be guarded for complete cataract may develop at some future time. Foreign bodies in the lens are discussed elsewhere.

Dislocation of the lens is not unusual. They may be partial or complete. When the latter occurs they are either in the vitreous, the anterior chamber, or outside under the conjunctiva. Dislocations within the globe mean secondary glaucoma sooner or later and because of this, removal is indicated before such a complication arises. Dislocated lenses become cataracts.

Cataracts, arising from puncture wounds in the anterior segment of the eye, usually progress quickly because of a considerable rupture of the capsule with exposure of the cortical substance to the aqueous fluid. These lenses swell rapidly which brings up the question of their immediate removal. If lens substance is not present in the aqueous, removal may be delayed until the general reaction of the eye subsides. The possibility of secondary glaucoma must be kept in mind. If there is considerable exposure of lens material, as much of it as possible is removed by physiologic saline irrigation. One must try to avoid the development of a thickened capsule which is difficult to remove except with scissors. It is therefore a good thing to remove as large a piece of the anterior capsule as possible at the time of removal of the lens material. If the anterior vitreous has been ruptured at the time of injury, it is preferable to wait, if possible, before removing lens substance in order to avoid loss of vitreous.

Age is a factor in deciding upon the type of operation to be used. The nucleus in the lens of an adult is quite firm and in most cases the cataract is best removed by the capsulotomy method employed for senile cataract extraction.

Due to the inequality of images, glasses are not prescribed for these patients except occasionally when requests are made in order to obtain employment.

INTRAOCULAR FOREIGN BODIES

The literature is voluminous on the subject of intraocular foreign bodies, their complications and methods for their removal. There is a paucity of records on visual results, because most of these injuries occur in industry to transient employees and final records are difficult to obtain. Because of the compensation laws, such records are necessary and valuable for reference.

In studying a foreign body case, the following questions present themselves: (1) What kind and of what character is it? (2) What structures has it entered; what damage has been done, and where is it located? (3) What is the present status of vision? (4) How shall it be removed?

1. The history will help to determine the kind of substance of which the foreign body

may be composed. The place, the tools, the machines used by the patient, also by those near by in case of flying chips, the type of metal, whether magnetic or not, and the time the accident occurred, give valuable information.

2. The use of the slit-lamp is very valuable in determining the place of entry to the eye and in the search of the anterior segment area for the foreign body. Transillumination of the globe aids in locating a hole in the iris and must not be overlooked. A careful survey of the entire lens is essential. A wide dilatation of the pupil will be necessary for this procedure; however, it is assumed that the anterior surface of the iris and angle have been examined before this is done. The course of the foreign body may be seen by a survey of the vitreous unless it has been obstructed by cataract or blood. When seen with the ophthalmoscope a metallic foreign body will appear black and shiny, not unlike a piece of coal. A survey of the retina is important, as the foreign body may be seen sticking in it or else the puncture wound of exit into the coats beyond may be found.

Localization plates are always made even though the foreign body may be seen. This is important alike for legal purposes and to aid the surgeon in knowing the size and position of the object. Haste in such cases is not essential and adequate time should be taken to study the conditions carefully before attempting the removal.

3. The status of the vision on admission to office or hospital is essential for both medical and legal purposes. The exact amount of vision and the preservation of vision are two points of great importance.

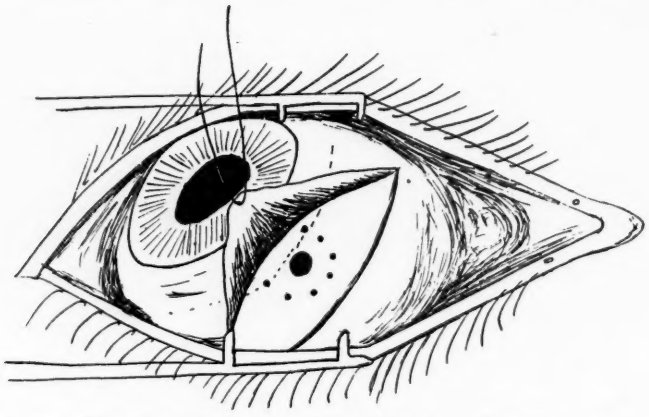

Fig. 4. Electrocoagulation with trephine opening in the center for posterior route extraction of the intraocular foreign body.

4. The method of removal is determined by the findings. If the foreign body is in the anterior segment of the eye, i.e., in the ciliary body, lens, iris, or anterior chamber, the anterior route is used. Cataracts may be produced by bringing a jagged piece of metal forward from the vitreous. If there already is a cataract, this route is used from the vitreous. Otherwise all posterior segment foreign bodies are removed by the posterior route.

It is interesting to note that since the advent of the electrocoagulation instrument, only one detachment of the retina has occurred and that was due to an early variation in the use of this method. The method is described as follows: A barrage of micropin coagulations is set up around the point where a 2 mm. trephine opening is to be made. Then the foreign body is extracted through the opening. If the piece of metal has been calculated to be larger than 2 mm., the opening is enlarged with a Von Graefe knife. The inferior nasal quadrant near the ora serrata is usually the site selected. It is believed that detachment of retina, as a complication of intraocular foreign bodies, may arise from other causes than the exit made for the extraction.

Care in the use of the electric magnet is important. It is not used as a diagnostic agent unless necessary. Under the direct vision of the ophthalmoscope, it may be gently used to test small clots of blood in the vitreous for movement or for magnetic properties of the foreign body. *X*-ray localization always precedes the use of the magnet. It must be emphasized however, that the *x*-rays have erred both in localization and in suggesting the presence of a foreign body. By repeating the *x*-ray after an unsuccessful application of the magnet, a shift in position may often be found. Do not attempt operative procedure after using a magnet until another *x*-ray is made. Experience has proved that application of the magnet repeated at several day intervals is important if there is suspicion that the body is magnetic. A Sweet hand magnet is preferred and used first, as undue magnetic force can do much harm to the anterior segment of the eye. The giant ring magnet of Professor Mellinger of Basle, made by Weis of London, which is used in this clinic, permits the patient to lie down for its application and allows more freedom of movement of the magnet tip.

Foreign bodies lodged in the retina and choroid have been observed to produce detachment of the retina and degeneration of the eye. By observing the movement of a foreign body in the retina under the action of a magnet, it is easily understandable why it is so difficult to remove the foreign body without damaging trauma. It is better to attempt to remove the metal through the sclera much as one attempts to approximate the position of a tear in the retina.

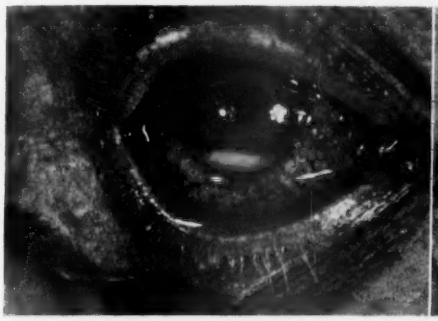

Fig. 5. Hypopyon following intraocular foreign body.

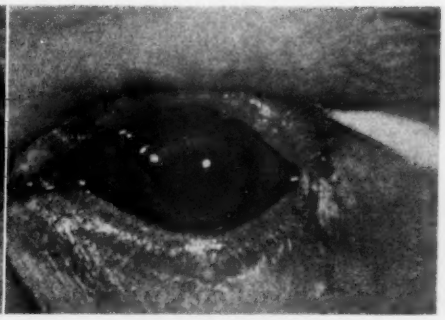

Fig. 6. The eye twenty-four hours later, following fever therapy in the Kettering hypertherm cabinet.

The lens tolerates surprisingly the presence of foreign bodies from the standpoint of irritating the anterior segment of the eye, as these seem to encapsulate themselves and remain for indefinite periods without producing complete cataract. Therefore there is no need of haste in removing them. Several such cases are under observation at the present time. There are some who advocate removal of these pieces of metal at once with equally good visual results. If it is evident that a cataract is developing, then it is best to proceed at once with the extraction of the metal, for there will be less autolysis of lens substance and toxic effects upon the anterior segment of the eye.

Foreign bodies may remain in the eye for years, as many records attest, without destroying the eye. Oxidation of a piece of metal has been known to take place, leaving no residue—while on the other hand reactions may take place early with rapid loss of the eye. Some eyes have been much worse after removal of the foreign body. Especially is this true of the non-magnetic group of metals, stone, glass, etc. On the whole, however, experience has shown that the best treatment is to remove the foreign body early, if at all possible.

FEVER THERAPY IN TRAUMATIC INJURIES OF THE EYE

The practice in this clinic has been to give foreign protein to every patient with a

penetrating wound of the globe or a severe traumatic ulcer of the cornea. All the prevailing types have been used for typhoid H-antigen is preferred because of the ease of administration and lack of sequelae. The dosage has ranged from 25,000,000 to 100,000,000 bacilli, depending on the individual case. The fever thus induced ranges from 100° to 102°F. This has not been considered quite sufficient, but higher dosage has not been used because of the possibility of grave systemic reactions. Just how valuable this form of treatment may be is difficult to determine. Some penetrating wounds do not develop infection anyway. It is questionable whether corneal ulcers are arrested by its use. Panophthalmitis and endophthalmitis have not been stopped. Because of the work of Dr. Albert L. Brown which showed a definite increase of the antibody content in the aqueous fluid following the use of typhoid antigen it has seemed advisable and necessary to administer it at the outset of all such cases.

Fever produced by the Kettering hypertherm cabinet has been extensively used by the Division of Ophthalmology. A fever of 105° to 106°F. for four to five hours, repeated as desired every three to seven days, has been the procedure. The results of its application for exogenous infections of the eye have been disappointing. A hypopyon of the anterior chamber has disappeared in twenty-four hours and the congestion of the eye has improved, but practically every infection carried into the vitreous of the eye went on eventually to a low grade endophthalmitis or to phthisis bulbi. A few patients still retain their sightless eyes and they appear quiet. No sympathetic ophthalmia has developed during or following this therapy. Whether this type of fever has any influence on this dreaded disease has not been answered. Some cases of corneal ulcers were arrested by its use, however, other standard treatment was being given at the same time. The use of fever therapy in certain endogenous infectious or allergic manifestations in the eye has been found to be definitely valuable, but it is not within the scope of this paper.

BURNS OF THE EYE

There is much room for improvement in the management of burns of the globe, whether thermal, acid, or alkali. Experimental work on burns in this clinic has demonstrated that free washing of the eye with water should precede the use of neutralizing agents. The results from 5 per cent tannic acid, mixed with water, glycerin, or an antiseptic ointment, have been disappointing. Because of its beneficial effect on the skin of the lids and the face, it was hoped that at least in alkali burns it would be of value.

In lime burns 5 per cent ammonium chloride has been at least as effective as 10 per cent ammonium tartrate. Trisodium citrate 8 per cent has not proved to be so effective as the ammonium salts. Since lime burns are not washed away to any degree by water, gently scraping away the lime deposits has been found to be very effective, thus preventing further chemical action upon the tissues.

Ammonia burns are considered the most severe. While much is said about the delayed reactions being due to the penetration of ammonia through the cornea, animal experimentation with chemical analysis of the aqueous has not borne out this statement.

Burns involving the sclera and limbus, if of second or third degree, are likely to produce sloughing of the adjacent cornea, due probably to the lack of nutrition from the injured loops of limbal vessels. Conjunctival or mucous membrane grafts, as advised by Denig for the scleral limbal area, are advocated and appear to provide a source of nutrition and an aid to corneal conservation. Tannic acid will provide a coagulum in this area, yet it does not prevent the breaking down of the cornea.

Applications of ointment and free manipulation of the lids daily with a glass rod still seems to be as good a method as any

yet found to prevent adhesions, although cellophane and thin rubber dam have been tried. Mucous membrane grafts continue to be used for adhesions of the lids to the globe as skin grafts are not very satisfactory in this region.

FRACTURES OF THE ORBIT

Fractures involving the bony structures of the orbit have become increasingly important since the majority are due to automobile and airplane accidents as well as to direct blows with fists. Fractures of the orbit are significant when viewed in the light of their relation to basal skull fractures with possible injury to the cerebral mass, along with the close relationship and likely trauma to the globe. Orbital fractures in our experience are generally due to direct blows with extension of the fracture lines into the bony orbit. The bones involved in order of frequency are: the zygoma; superior maxilla; frontal bone; lamina papyracea of the ethmoid; and the lacrimal bone, while injury of sphenoid and palate are quite infrequent.

The fact that the malar bone makes up a large portion of the floor and lateral wall, as well as the inferior and lateral margin of the orbit, and forms the prominence of the cheek, accounts for the frequency of fracture. Fracture lines may run into the frontal and maxillary sinuses. Displacement is in the direction of force which is generally downward and backward with rotation on its own axis. If fractures extend into the antrum, there is apt to be epistaxis with subsequent danger of infection. If there is enough displacement, ocular complications such as subconjunctival hemorrhage, orbital hemorrhage with decreased motility of the globe, displacement of the globe with diplopia and emphysema, may result. Involvement of the infraorbital nerve is not infrequent.

Diagnosis in fractures of the malar bone and maxilla hinges essentially on inspection, palpation, comparison with the opposite orbital rim, and the roentgenogram. Treatment is early reduction, unless swelling has progressed to the extent of interference, in which case proper treatment includes waiting for the swelling to subside before reduction is attempted. Although every case is individualized, the method of reduction here centers around the Caldwell-Luc approach. After reduction, the antrum is firmly packed, the buccal incision is closed and an antromeatal window is made for drainage. Any loose fragments of bone and all blood clots are removed. If malocclusion is present, close coöperation with the oral surgeon is essential.

Fractures of the frontal bone generally involve the frontal sinus and here there are the added dangers of intracranial injury and infection. Ocular complications, such as ecchymosis of the conjunctiva, orbital hemorrhage with decreased motility and exophthalmos, emphysema of the lids and orbital contents, enophthalmos, sudden blindness, corneal wounds, dislocation of the lens, traumatic mydriasis, iridodialysis, intraocular hemorrhage, lesions of the choroid, and detachment and rupture of the retina, are frequent. Treatment of a fracture involving the frontal bone includes the close coöperation and services of the neurosurgeon. If an external wound is present and the inner wall is not damaged, the external wound is closed after establishing adequate drainage by way of the nasofrontal duct. If the inner wall is damaged, the external wound is made larger and, if depressed, the fragment is elevated; if there is an opening in the inner wall it is enlarged and the dura exposed; if the dura is torn it is repaired with a free graft of fascia lata. In these latter conditions external drainage is preferable and contact between the nose and sinus cavity must be prevented.

Fractures of the lamina papyracea of the ethmoid are generally due to perforating injuries. They are associated with epistaxis, orbital hemorrhage and emphysema. Conservative and expectant treatment is generally all that is necessary, along with thorough cleansing of the outer wound and nasal cavities. The same holds true for

fractures of the lacrimal, sphenoid and palate bones. In these, complications such as sudden blindness due to hemorrhage into the sheath of the optic nerve or injury to this structure by a fracture through the optic foramen may result, as well as injury to the lacrimal sac or nasolacrimal duct.

SUMMARY

1. Restoration of proper function and appearance of the lids after injury, requires a knowledge of the anatomy and physiology of the parts and of the fundamental principles of plastic surgery. Many emergency operations are poorly done.

2. The extraocular muscles themselves are rarely injured but their functions are often disturbed by contusion of the nerve supply, fractures and lacerations.

3. Contusions of the globe, however simple, often prove serious to sight; therefore every eyeball so injured should receive careful scrutiny both inside and out.

4. The importance of detection of minute perforations of the globe is emphasized because of their aid in detecting possible intraocular foreign bodies. Bed rest and careful observation for complications in all perforating wounds of the globe are indicated. Sympathetic ophthalmia has not developed in this group.

5. Traumatic cataracts may arise from contusions as well as from penetrating wounds of the globe and should be removed at the proper time, provided the posterior segment of the eye is intact.

6. Intraocular foreign bodies may or may not prove serious to sight; their character and location plus the element of infection are the determining factors. All foreign bodies should be removed as soon as detected whenever possible. Sometimes, however, haste makes waste and should be avoided.

7. Injection of foreign protein in some form to produce fever and stimulate antibody formation is widely used in the practice of ophthalmology. The amount of fever produced seems to be the criterion of its effectiveness. Typhoid H-antigen is generally preferred for prophylactic purposes, although its exact value is difficult to judge. Induced fever by the use of the Kettering hypertherm cabinet does not destroy exogenous intraocular infection.

8. Second and third degree burns of the eye are destructive to sight and disappointing to treat. Research investigation so far has contributed little to improvement in method of treatment.

9. Fractures of the malar bone and zygomatic arch are the most disfiguring and may produce binocular imbalance and asymmetry of the eyes. Intraocular damage is also a possibility. Repair should be done if possible before swelling occurs or immediately after it subsides. The Caldwell-Luc operation is the method of approach mostly employed. Fractures of the optic foramen may produce optic atrophy.

FRACTURES AND DISLOCATIONS OF THE CERVICAL SPINE

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THE recent revival of interest in the treatment of injuries of the spine has resulted from recognition that the adequate reduction of the displacement often leads to complete cure or at any rate to marked reduction in the residual disability. This has proved as important in the injuries of the cervical region as in those occurring elsewhere, for aside from those injuries produced by the hangman's knot, the spinal cord is often not seriously injured and is frequently capable of recovery if the displacement is reduced.

Hospital practice and experience in these injuries must vary greatly with the character of the community served and with the qualifications of the staff. Thus, the orthopedic service is likely to see many patients whose complaints are chiefly pain, deformity and stiffness of the neck, whereas the neurosurgical department will see others who have varying degrees of involvement of the nervous system. The combined opinion of these two departments in this hospital, however, based on observations extending over ten years, is that most of the cases that are brought to the hospital alive have no, or only slight injury to the cord and that even many of those with signs of a cord lesion may be expected to show progressive recovery when the pressure on the cord has been relieved.[1]

It is not the function of a symposium such as this to deal with the subject as in a textbook, but it is rather to draw attention to ideas that are new and to viewpoints that have changed. I shall say nothing, therefore, in regard to the anatomy, the etiology and the diagnosis except to point out that any patient who has had an injury of the neck and who continues to complain of pain or stiffness or who holds his head in a peculiar attitude, should be submitted to *x*-ray examination. The *x*-ray may show a forward dislocation of a vertebra with or without fractures of the anterior lips of the bodies or fractures of the pedicles or articular processes. The commonest lesion is a forward dislocation of the inferior articular facets of the upper vertebra over the tops of the upper articular facets of the lower.

The outstanding impressions left by our experience with such cases are these:

1. The reduction of the displacement is imperative, for although no neurological signs may be present at the time, they are altogether likely to develop later, either as the result of further sudden displacement or of more gradual displacement caused by the weight of the head.

2. It is imperative also because when such patients again assume the upright position, even if they have no cord signs, they have intolerable pain in the neck and in the distribution of the spinal nerves which leave the spinal column in the neighborhood of the injury.

3. Efforts to reduce the dislocations by manipulation are attended by such appalling risk of damage to the spinal cord that they should not be employed. I saw one such disaster and it was enough.

4. The successful reduction of the dislocation by no means ensures that it will not recur, for it frequently does so as soon as the patient sits up and in spite of splints, collars and plaster jackets. Further, it may recur weeks or months after the reduction, particularly in cases in which this was obtained a week or two after the injury. In such cases the torn or avulsed ligaments have not had a chance to heal properly and so remain permanently weak.

5. Reduction of the displacement in most cases can be accomplished with complete safety by the use of skeletal traction applied to the head.

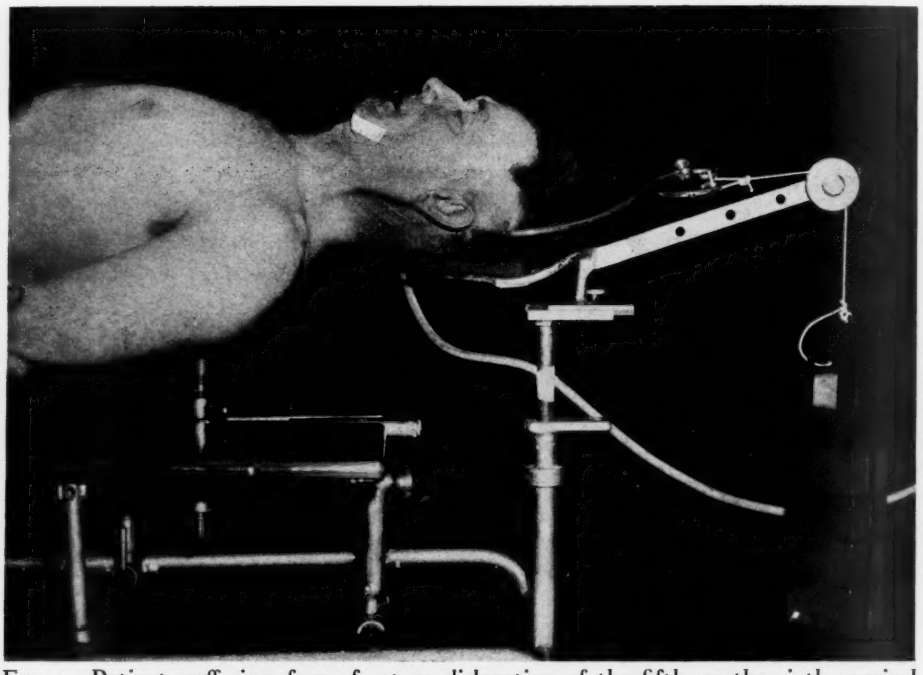

Fig. 1. Patient suffering from fracture dislocation of the fifth on the sixth cervical vertebra. He has been anesthetized and submitted to heavy traction with tongs preparatory to application of plaster jacket.

6. In those cases in which reduction cannot be accomplished with skeletal traction because of the locking of the articular facets, an open operation which exposes the facets enables the surgeon to disengage the locked processes under direct vision and without risk of damaging the cord.

7. Recurrence of the displacement after such operative reduction can be guarded against by fastening the two vertebrae together by fine steel wire passed around the laminae or spines. And the risk of late recurrence can be eliminated by bone grafts laid in the spines or on the laminae and articular facets.

8. Skeletal traction alone or in combination with operative exposure of the dislocated articular facets will accomplish reduction months or years after the injury and when combined with successful fusion of the adjacent vertebrae will give permanent results.

9. In those patients who are having respiratory difficulty from paralysis of the muscles of respiration by pressure or edema ascending to involve the third and fourth cervical cord segments, the Drinker respirator may be used. Respirations can be maintained until recovery of cord function develops after reduction of the displacement.

The importance and feasibility of reduction of the displacement in fractures and dislocations of the spine has only recently impressed itself on us. The practice in this hospital, as in most others, has been to leave the displacement alone for fear of doing greater harm in those cases without neurological signs and to relieve possible pressure by laminectomy in those in which paralysis was a feature. The demonstration by Davis,[3] however, that compression fractures could easily be straightened out without risk has caused much speculation as to whether similar methods might not be applied to more serious displacements and even those in which there is an associated injury of the cord. One cannot but be impressed with the comparative futility of laminectomies done to relieve pressure on an injured cord where no measures are taken to reduce displacements of the

vertebrae and nothing done to get rid of the gross distortion of the spinal canal. One cannot forget also the almost inevitable

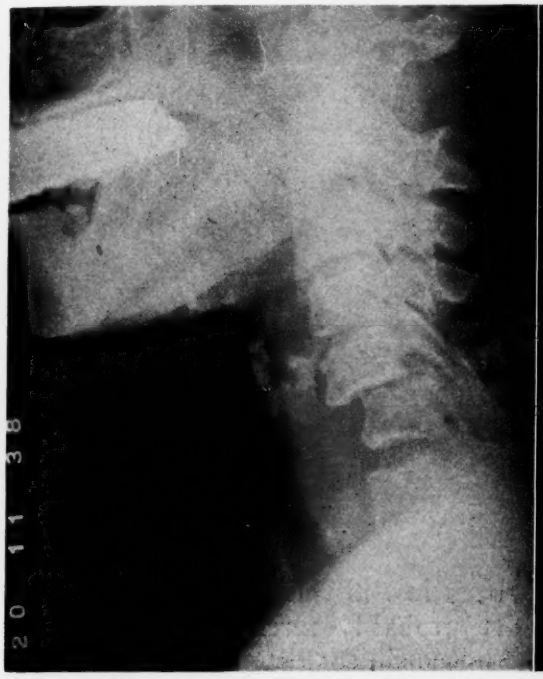

Fig. 2. Roentgenogram of patient with gross forward dislocation and slight crush fracture of cervical vertebrae.

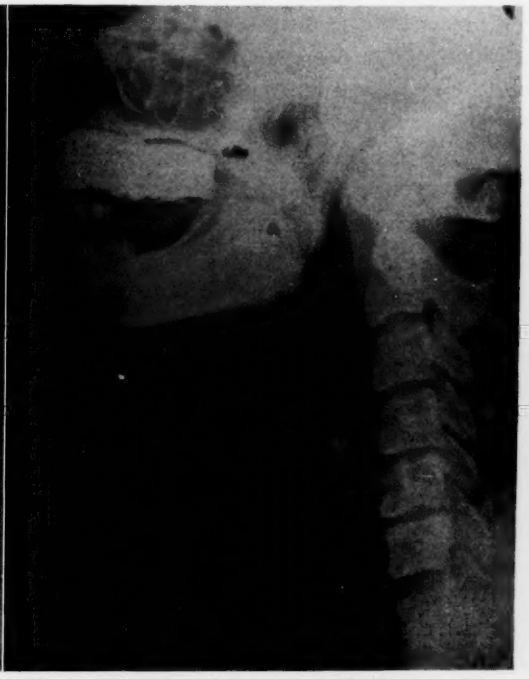

Fig. 3. Same patient ten weeks later, after complete reduction of the displacement by skeletal traction. Note the bridge of new bone fusing the anterior border of the injured bones.

increase in the deformity, usually a kyphosis, that will occur when the patient again assumes an upright attitude.

The application of the principle of skeletal traction to the fractures and dislocations occurring in the cervical region has solved many of the difficulties. With the traction applied directly to the head by means of tongs, hooks or wires, it is possible to reduce the displacement painlessly and safely, to get rid of the compression of the cord without laminectomy, and to restore the smooth continuity of the spinal canal.

The technique employed in this hospital[2] is best illustrated in Figure 1. As soon as the diagnosis is made, either from neurological signs or from physical examination of the neck and from *x*-rays, tongs are fastened into the skull and heavy traction applied. A small area of skin just below the most prominent part of each parietal bone is shaved and cleansed and the area anesthetized with novocaine. Tiny incisions allow the points of the tongs to traverse the skin and to reach the skull. The points are then engaged in the bone by a light sharp tap with a hammer and the handles locked. The lock prevents the points from becoming disengaged from the skull or from sinking too deeply into it.

The advantage of skeletal traction over older methods such as traction with the leather chin cup halter, is great. It is painless and comfortable, and as in the case of skeletal traction applied to the extremities, effective. Now that it has been shown from experience with scores of cases that it is safe there is no doubt it will replace all other methods of applying traction.

The subsequent management will depend on the presence or absence of signs of injury of the cord.

Thus, if high cord injury is present, such as might accompany injury of the odontoid process or third cervical vertebra, the indications are to reduce the displacement and to arrange for artificial respiration until a sufficient degree of recovery has been established to enable the patient to

breathe by himself. This has been accomplished in this hospital by my colleague, Dr. E. H. Botterell, who placed the patient in the Drinker respirator apparatus and maintained constant traction on the head and neck by means of tongs.

In cases of injury to the cervical spine below the level of the fourth vertebra, in which there has been injury to the cord, the tongs are applied and the patient put to bed on his back with the head hanging over the upper edge of the mattress or a pillow. This ensures reduction of the displacement and prevention of its recurrence and it allows, without much risk, the frequent turning of the patient which is necessary to prevent the onset of bedsores. In such cases very narrow tongs or the special tongs described by Crutchfield[4] which are narrower than the head, are preferable, as they do not interfere with the turning of the patient.

The third group, which in our experience is by far the most numerous, is composed of cases of forward dislocation or fracture-dislocation of the fourth, fifth, sixth or seventh vertebrae and without serious injury to the cord. These cases are at once put on the special apparatus illustrated in Figure 1, the displacement completely corrected by heavy traction, up to 30 or 35 pounds, and by raising or lowering the chest and head to make sure that the traction and leverage are in the proper direction. When the *x*-ray shows complete reduction a plaster Minerva jacket extending from crown to pelvis is applied. The tongs are then removed. (Figs. 1, 2 and 3.)

An outstanding feature of the subsequent history of all types of fracture dislocation of the cervical spine is the tendency to recurrence of the deformity. This is particularly the case in patients in whom there has been a forward dislocation combined with a crush fracture of the anterior edge of the vertebral body below the dislocation, and in those in whom there has been a fracture of the articular processes. It is prone to occur, however, even in those in whom the forward dislocation is uncomplicated by fracture and on the slightest provocation. Thus it will occur while the patient is lying flat on his back if he raises his head to the slightest degree even when the traction is still on, so that it is necessary to maintain the backward bowing of the neck at all times to guard against slipping. It will occur almost every time in a Minerva jacket if this extends downward only to the middle of the chest and will occur also in jackets extending to the pelvis unless these are perfectly applied. Another disturbing observation is that even in cases in which the dislocation has been reduced perfectly and the position maintained for several weeks, a gradual slipping may develop later which may go on to the production of local pain and stiffness and even of signs of involvement of the cord. This seems particularly likely to happen in cases in which the primary reduction has been delayed or in which considerable time has been lost in the correction of recurrences. It probably results from failure of the ruptured ligaments to heal properly before strain is applied.

This strong tendency to recurrence of the deformity has attracted very general attention and has led us, along with others, to resort to operative measures to prevent it. Thus we have on several occasions exposed the spines of the two vertebrae involved and fastened them together with fine stainless steel wire. With this we have sometimes combined measures to ensure fusion of the adjacent articular facets and laminae by the Hibb's method or of the spines by the introduction of an Albee graft. A successful fusion eliminates the possibility of late slipping.

We have been so impressed with the tendency to recurrence that we now consider seriously in every case whether or not an operation should be done. There is no doubt that it is not necessary in all cases but as time goes on we find that we are wiring and fusing more and more. The importance of this is emphasized by Cone and Turner.[5] Our present plan is to submit to such an operation all cases in which our experience has taught us that slipping is likely to occur and all cases in which a

tendency to slip has revealed itself while other methods are being employed.

In addition to cases suffering from recent fractures and dislocations there has been a number of cases admitted to hospital weeks and months after the injury, in which the displacement has never been reduced or in which it has recurred. These all require operative treatment. In the early days of skeletal traction we found that sometimes it was possible, even months after the injury, to reduce a gross displacement by heavy traction. This always recurred, however, as soon as the traction or the plaster jacket was removed. In many cases, on the other hand, heavy traction failed to disengage locked articular processes, so that it became necessary to expose these processes in order to unlock them. We have usually had to clip off the upper edge of the superior articular facet of the lower vertebra to enable us to lever the inferior processes of the upper vertebra into place. A skilled hand manipulating the head at this stage is very helpful. Once the deformity has been reduced the adjacent spines should be fastened together with steel wire and measures taken to fuse the laminae and facets on the spines. If it was necessary to expose the articular facets the cartilage should be removed from them with a curette and some chips and slivers of bone, obtained from the leg or ilium, so laid on the freshened surfaces as to bridge the articular processes and laminae. If such deep exposure was not necessary a simple single or double graft tied into the spines will be sufficient.

In cervical injuries with associated cord damage, as in spinal injuries elsewhere, the complications most feared are bladder infection and bedsores. These, however, can be minimized greatly if certain precautions are taken.

The most effective way to prevent infection of the paralyzed bladder or to clear up the infection if it is already established is to introduce the tidal irrigator described by Munro.[6] In our experience this has been spectacularly successful and if a little care and patience are exercised at the beginning it can soon be turned over to the management of the patient himself. It has solved one of the most miserable accompaniments of fracture of the spine.

The prevention of bedsores in the sacral region depends on keeping the parts clean and dry and on frequent changing of the patient's position so as to take the pressure off the area. With skeletal traction this can be done safely and is one of the chief reasons for continuing the traction after the primary reduction has been made. The only precaution necessary is to avoid gross displacement of the head when the patient is being turned. In those cases in which traction is to be maintained for a long time the weight should be reduced to 8 or 10 pounds as soon as reduction is complete, as it has been found that heavier traction maintained for twelve hours or more may produce paralysis and anesthesia in the arms. During the turning movements the weights may be increased temporarily to 15 pounds.

A retrospect of our experience of the past ten years has led us to a decidedly more hopeful view of the prognosis. As far as those cases are concerned that are uncomplicated by cord injury there is no reason whatever to anticipate anything but complete cure. Involvement of the cord is of course serious but even when this is present it is often possible for recovery to take place if the deformity is reduced and if the patient can be kept from dying in the early stages from respiratory failure or urinary infection. Laminectomy still has its place where fragments of bone are compressing the cord but in many instances skeletal traction aided by the Drinker respirator and the tidal irrigator is preferable and gives the patient a much increased chance of recovery.

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THE FASCIAL SPACES OF THE NECK IN ACUTE INFECTION*

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ALTHOUGH the importance of fascial planes in acute infections of the extremities is well understood by most physicians, the relation of the spread of infection in the cervical region to the fascial architecture is much less appreciated. The course of infections of the neck is determined by definite fascial planes that may act as barriers to localize infection or may direct the spread of an acute suppurative process to involve fascial compartments in the mediastinum. Hare states that of seventy-eight cases of pyogenic mediastinal suppurations, seventeen, or 22 per cent, were of cervical origin. Pearse collected 110 cases of suppurative mediastinitis and found perforation of the cervical esophagus accountable for 58.1 per cent, suppurative cervical adenitis 11.8 per cent, retropharyngeal abscess 10 per cent, peritonsillar abscess 7.2 per cent, tracheotomy 5.5 per cent, spondylitis 2.8 per cent, thyroidectomy 2.8 per cent, and Ludwig's angina 1.8 per cent.

If the superficial types of infections such as furuncles are omitted, infections of the neck may be divided into four general groups. In this paper, only Group One will be discussed.

1. Acute suppurations secondary to infections elsewhere. Of this group, Boemer reviewed seventy-five cases and found thirty-eight from retropharyngeal abscess, eleven from deep cervical glands, nine from lower third molar, seven from superficial cervical glands, three from tonsils, two from mastoid, and five from miscellaneous sources including carcinoma and fractures.

2. Specific infections such as tuberculosis, syphilis, actinomycosis, blastomycosis, and tularemia.

3. Infected cysts and tumors, including cystic hygroma, lymphangioma, and degenerating malignant nodes.

4. Thyroiditis.

Fascial planes classified by their relation to the spread of infection may be divided into two groups: those associated with muscles, and those surrounding viscera and vessels. The muscular fascial planes are always ultimately inserted into bone, thereby sharply limiting infections in these spaces. The viscerovascular fascial spaces extend along vessels and viscera in continuity with these structures, thereby allowing infection in them to pass readily from one region to another. In the face, three muscular fascial spaces have been described: the space of the body of the mandible, the masticator space, and the parotid space, and one viscerovascular space, the pterygopharyngomaxillary or the lateral pharyngeal space.

In the neck there are also definite fascial planes of both types. After the skin, subcutaneous tissue, and platysma muscles have been reflected, the first muscular fascial plane of the neck encloses the sternocleidomastoid and trapezius muscles. This fascia is continuous with the fascial boundaries of the masticator space, and blends with the periosteum of the clavicle and sternum. Deep to this plane is found the second muscular fascial plane in which lie the sternohyoid and omohyoid muscles. Above it joins the first layer of fascia at the hyoid base to form the fused fascia, while below it splits at the sternum into two layers to form the suprasternal space. Laterally it blends with the periosteum of the posterior border of the clavicle and with the upper border of the scapula where the omohyoid is inserted. The plane then

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continues around the neck between the trapezius and the deep muscles of the neck to insert into the ligamentum nuchae. The posteriorly surrounds the aorta. Laterally it passes with the intercostal arteries to merge with the parietal pleura. This large

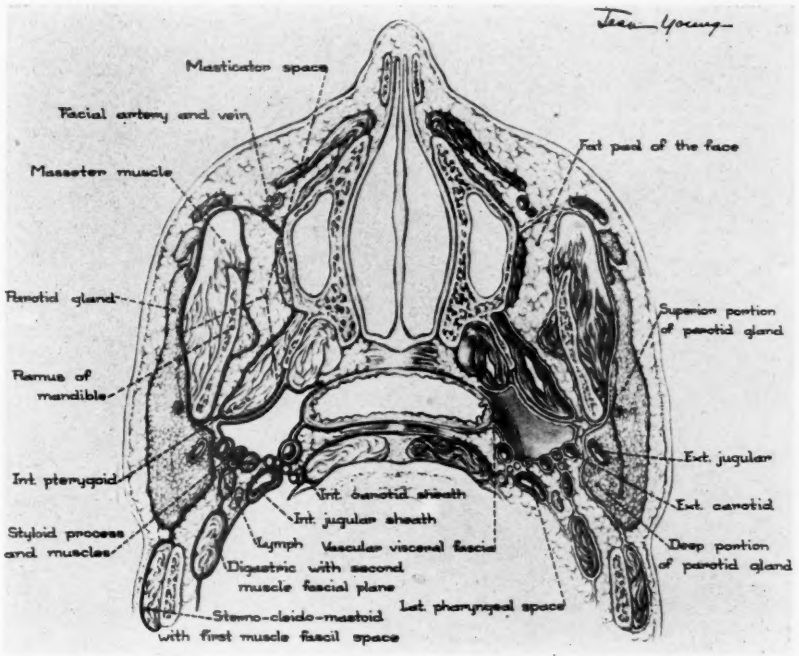

Fig. 1. Horizontal section demonstrating the different fascial planes and potential anatomic spaces. (From Coller and Yglesias, in *Surg., Gynec. & Obst.*, 60: 277, 1935.)

suprasternal space is not important as far as infections of the neck are concerned. It may be infected through stab wounds, osteomyelitis of the hyoid bone and from the lymphatics. The third muscular fascial layer is composed of the fascia enclosing the sternothyroid and thyrohyoid muscles; it continues above to the hyoid bone, laterally to fuse with the fascial sheath of the internal jugular vein, and inferiorly it is attached to the posterior border of the manubrium and first rib. This space is seldom infected and its only practical application is that the surgeon following this space laterally will meet the internal jugular vein.

The viscerovascular fascia, as its name implies, envelops the viscera of the neck and mediastinum, carotid sheath and aorta, forming a cylindric covering of the pharynx, larynx, aorta, and its branches which ascend into the neck. Within the thoracic cavity this fascial layer blends anteriorly with the pericardial sac and space is of the greatest importance to the surgeon since it connects the mouth, throat, and pharynx and is the route along which infections commonly pass. For a better understanding of this region, it may be divided into several parts.

The fascia lying posterior to the pharynx has been called the buccopharyngeal fascia; the layer lying anterior to the trachea, the pretracheal fascia; and that portion surrounding the aorta and its branches, the vascular sheath. The lateral pharyngeal space, which may be infected from any of the three important fascial spaces of the face and from the pharynx and tonsil, can act as portal of entry to the large viscerovascular space.

The submaxillary gland is enclosed by that portion of the viscerovascular fascia that surrounds the pharynx and covers the floor of the mouth. This gland with its coverings is separated from the parotid space and subcutaneous tissue by the fused fascia of the first and second muscu-

lar fascial planes of the neck. Posteriorly the fascia covering the gland is connected to the external carotid sheath and forms the buccopharyngeal fascia of the pharynx and the retroesophageal fascia of the esophagus. Infections arising from the

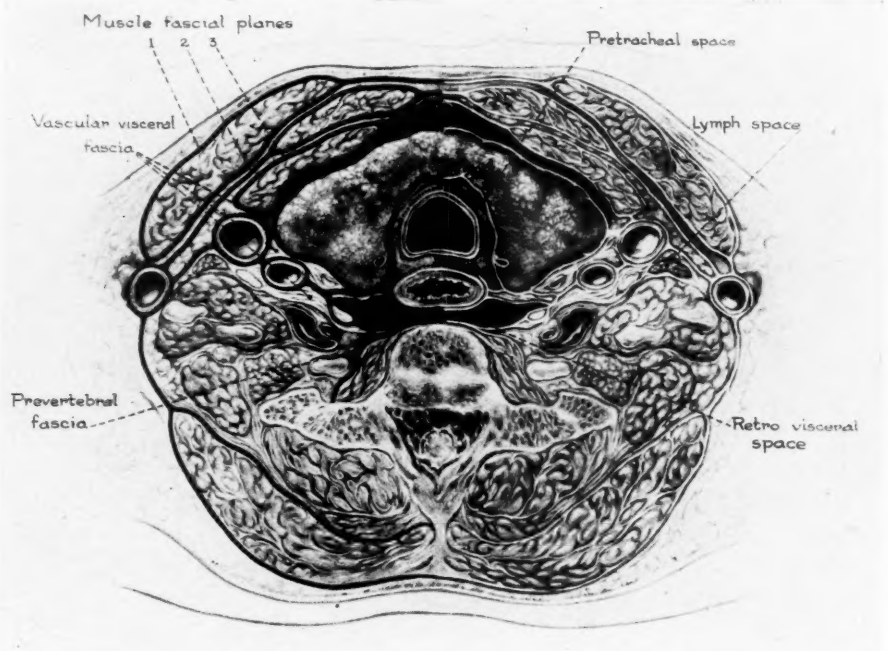

FIG. 2. Horizontal section at the neck showing dissection of the fascial planes and spaces. (From Coller and Yglesias, in *Surgery*, 1: 323, 1937.)

the floor of the lateral pharyngeal space. Infections of the submaxillary gland may perforate and infect the viscerovascular space. Diagnosis is not difficult. The infection manifests itself as a hard, tender swelling over the submaxillary triangle. The mouth is opened with difficulty and movement of the tongue is painful. Although some of these deep infections subside with conservative treatment, if the patient continues to run a septic course after twenty-four to forty-eight hours, operation is indicated. Removal of the gland has proved the best method of attack.

The pretracheal fascia is that fascia which encloses the larynx, trachea, and thyroid gland. It descends into the mediastinum surrounding the tracheobronchial lymphatic system, the arch of the aorta, and the right branch of the pulmonary artery to blend finally with the pericardial sac. Laterally in the neck, the fascia merges with the sheath of the common carotid artery. Posteriorly it continues to form lateral wall of the pharynx, such as peritonsillar abscess or infections of the lateral pharyngeal space, may extend down to infect the entire pretracheal space. Perforations of the anterior wall of the esophagus may also reach this space. That portion of the viscerovascular fascia surrounding the carotid artery and internal jugular vein, forms the true sheath for these vessels and may be infected from the lateral pharyngeal space, but if this occurs the infection usually remains limited to the sheath.

The fascia that covers the posterior wall of the pharynx and esophagus is the retrovisceral portion of the viscerovascular system. Between this and the prevertebral fascia is a large and important space bounded laterally in the neck by the fusing of these fasciae at the point where they surround the cervical sympathetic chain. Above it extends to the basilar process of the skull and is continuous below to the diaphragm. In the thorax the lateral

boundaries are formed by the expansion of the sheath covering the descending aorta as it passes posterior to the parietal pleura

fection of the retrovisceral space passing downward to expand laterally between the pleurae and the lateral expansion of the

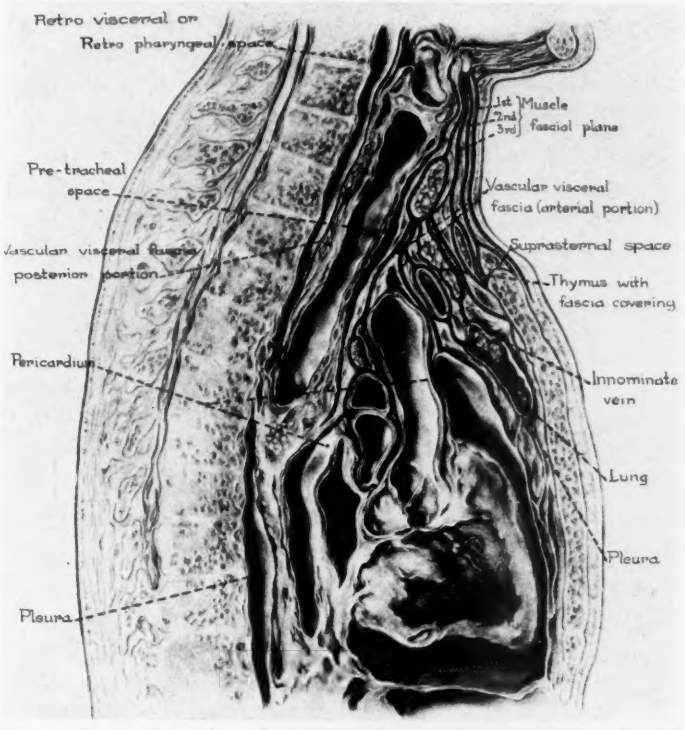

Fig. 3. Sagittal section through neck and thorax showing fascial planes and spaces. (From Coller and Yglesias, in *Surgery*, 1: 323, 1937.)

to join the posterior wall of the thorax. Below the level of the bifurcation of the trachea, the space becomes very small and may be occluded by the close approximation of the two pleurae. The clinical importance of this pathway is obvious. Its intimate relation to the vertebrae, esophagus, and lymph nodes exposes it to infection from all sides. Pyogenic and tuberculous infection arising from any bone adjacent to this area, including the basilar process of the skull, the petrous portion of the temporal bone, the cervical and dorsal vertebrae, and the posterior ends of the ribs, may spread to this space.

Infections in any of the cervical and upper dorsal vertebrae will first produce a prevertebral abscess that is limited by the prevertebral fascia, muscles, and ligaments, and will remain localized here for varying lengths of time. Eventually, however, perforation will occur with secondary in-

aortic sheath as it attaches to the thoracic wall. If the infection originates in the posterior end of the ribs, the spread of the infection will be in a reverse direction from the ribs along the space between the pleura and the lateral expansion of the sheath of the descending aorta to the retrovisceral space. For these reasons, infections in the retrovisceral space above the fourth dorsal vertebra, may best be drained by an incision in its upper portion in the neck, and infections below this point must be drained by dorsal mediastinotomy effected by posterior rib resection.

Clinically, this abscess will give rise to a variety of well known signs and symptoms, depending upon its point of origin. Dysphagia, dyspnea, dysphonia, and a bulge in the posterior pharyngeal wall are generally seen. Infants and children will have as their chief symptom dyspnea, since the posterior wall of the trachea is less

fixed and the trachea is more easily compressed than in adults. In adults dysphagia will often be the first symptom. *X*-ray examination will show an increase in width of the retropharyngeal space in both the frontal and lateral projections.

Drainage of infection in the retrovisceral space may be carried out through an incision made along the anterior border of the sternocleidomastoid muscle at any desired level between the hyoid bone and the sternum, depending upon the level of the infection. Cervical mediastinotomy is carried out by division of the skin, subcutaneous tissues, and platysma muscle; the first muscular fascial plane is divided along the anterior border of the sternocleidomastoid muscle; the second muscular fascial plane is divided along the lateral border of the omohyoid muscle; and the third muscular fascial plane is incised and separated from the sheath of the internal jugular vein. The lateral or lower border of the thyroid gland is lifted, and at the lower border of the thyroid is encountered the fascia passing from the thyroid to the venous portion of the viscerovascular fascia and to the thymus gland. After incising this fascia, the upper portion of the pleural-pericardial space has been opened and drainage is accomplished. This approach is best carried out on the right side, as the pleura and esophagus meet at a lower level than on the left, consequently there is less chance of inadvertently opening the pleura during the dissection. Postural drainage and intermittent suction at frequent intervals are helpful after the drainage tube is placed. In early infection of the space, incision through the posterior pharyngeal wall at point of maximum swelling will usually be adequate, but if the infection has passed down, or originated in the lower portion of the space below the fourth cervical vertebra, drainage will necessarily be carried out by external thoracotomy.

Infection of the cervical lymph glands is often encountered by the surgeon. The superficial group of glands lies under the platysma muscle along the external jugular vein. When infected, they usually form localized subcutaneous abscesses and do not communicate with other fascial spaces of the neck. The deep group of nodes, however, lies along the great vessels of the neck in a space bounded anteriorly by the sheath of the internal jugular vein and common carotid artery, posteriorly by the fascia covering the anterior scalene muscle. The space extends upward to the mastoid and continues down to the supraclavicular fossa. Here the nodes end in the angle between the subclavian and internal jugular veins. Infection extending down this chain of nodes may pass directly to the axilla.

SUMMARY

A description of the fascial spaces of the neck with practical application to the routes of infection has been given. The importance of a knowledge of the fasciae and fascial spaces in anticipating the spread of infection is obvious.

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THE SURGICAL ASPECTS OF OTITIS MEDIA, PERITONSILLAR ABSCESS AND RETROPHARYNGEAL ABSCESS

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IN the strictest sense of the word neither acute otitis media, peritonsillar abscess nor peritonsillar abscess can ordinarily be said to constitute a surgical emergency. Nevertheless each of these conditions may, through the development of certain complications or through delayed or inappropriate therapy, constitute a threat to the patient's life unless prompt surgical measures are applied. For this reason they justify consideration in this article.

OTITIS MEDIA

It is manifestly impossible within the space here available to discuss the many and varied clinical features of this common condition. Of primary concern to the practicing physician is, first, the ability to recognize the existence of an acute otitis media; second, to apply appropriate therapy; and third, so to appraise the subsequent course of the disease as to anticipate the developments of the serious complications which may ever lie in the wake of an apparently trivial infection.

To this end it is essential that a reasonable degree of skill be acquired in methods of examination of the tympanic membrane since, more than any other single anatomic structure, it holds the key to the exact character of the pathology in the middle ear. The drum can be satisfactorily inspected only when a good and preferably artificial light is thrown into the external canal either indirectly by reflection from a head mirror or directly by means of an electric otoscope. The latter has the disadvantage of introducing a confusing element of magnification which tends to distort the characteristic appearances observable in the presence of an acute middle ear infection. While some practice is necessary in order to master the technique of mirror reflection the physician will be well repaid in his efforts to achieve proper manipulation of the aural speculum and the direction of an unobstructed beam of light against the drum.

No satisfactory estimate of the degree of middle ear pathology as manifested by the tympanic membrane is possible without some knowledge of the normal structures for comparison. While there is no single typical appearance of the tympanic membrane, examination of a relatively small number of uninflamed drums will serve to orient the practitioner and enable him to appreciate the classical landmarks described in all textbooks. Chief among these are the pearly gray color of the membrane, the definite anterior and inferior declination of the slightly concave surface and the triangular light reflex, broken or intact, radiating from the center or umbo anteriorly toward the periphery of the anterior inferior quadrant. In addition, one must be able to recognize the handle of the malleus as it runs from the umbo superiorly and anteriorly to a small white dot, representing the so-called short process from which convex curved folds radiate posteriorly and anteriorly to demarcate the small superior portion of the drum known as Shrapnell's membrane. (Fig. 1.)

In general it can be assumed that the great majority of acute middle ear infections originate as a nasopharyngitis which by extension via the eustachian tubes come to involve the mucosa of the tympanic cavity. The condition is far commoner in children than in adults, due to the more direct course of the eustachian tube and the frequent presence of obstruct-

ing masses of lymphoid tissue in the nasopharynx which, lying in juxtaposition to the eustachian tube orifice, form an easy means of access of infection.

loses its normal luster, shows an increased hyperemia and often a surface loss of epithelium with an accumulation of irregularly scattered plaques of fibrin.

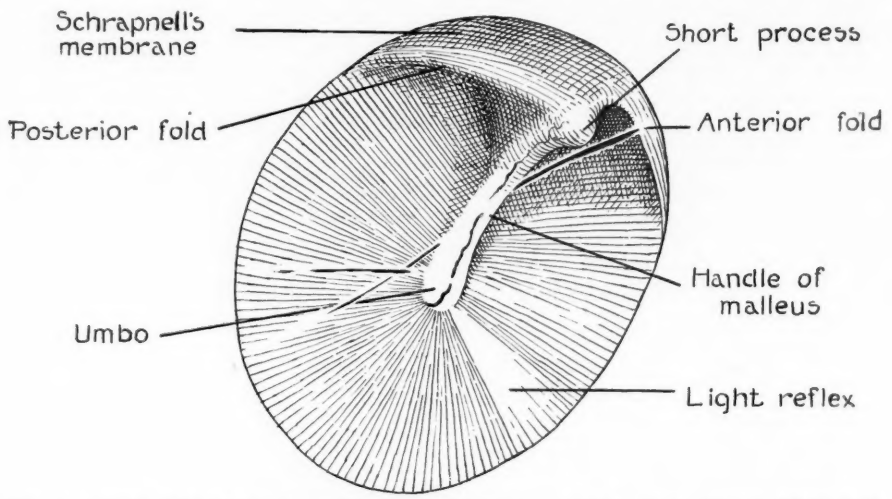

Fig. 1. Landmarks of the normal tympanic membrane (right ear). (From Richards' "Otolaryngology in General Practice," Macmillan.)

That some degree of middle ear infection is beginning to complicate an acute nasopharynx is first manifested by a sense of fulness or obstruction to normal aeration of the middle ear and by a definite hyperemia and retraction of the drum membrane. There may be no fever and only minimal discomfort. Such a situation may frequently extend no further and with appropriate measures to reduce nasal congestion and restore normal tubal ventilation, prompt resolution may occur. On the contrary, the early signs of tubal closure may be but the forerunner of further trouble. With continued congestion of the tympanic mucosa and absorption of air from the tympanic cavity there takes place an exudation of fluid which through the pressure occasioned by it produces the classical symptoms of more serious middle ear pathology, i.e., deafness, pain and the bulging or convexity of the drum. As a further result of this pressure against the drum there results a more or less complete loss of the characteristic landmarks of the drum, particularly of the light reflex, the short process and the handle of the malleus. The drum surface

Even in such an advanced state of middle ear disturbance it is still possible for normal resolution to take place and for the accumulated fluid to drain spontaneously through the eustachian tube, provided that active bacterial infection of this fluid does not complicate the situation. The entrance of this more serious factor into the picture is manifested by a febrile reaction much more pronounced in children than in adults, by more severe pain resulting from elaboration of bacterial toxins, and by a still more pathologic appearance of the drum membrane, so that it now bears scarcely any resemblance to the normal drum. Under these circumstances there can be no doubt as to the advisability of incision of the drum membrane in order to provide drainage for the purulent fluid within the middle ear cavity, which in all probability will otherwise be forced to provide its own outlet via a spontaneous perforation of the drum. Such drainage is often inadequate and to await its occurrence subjects the patient to needless and prolonged pain. Moreover, it is the opinion of otologists that awaiting spontaneous drainage is often a predispos-

ing factor in the development of such subsequent complications as mastoiditis.

Up to the point of assurance of the existence of a frank purulent otitis media the physician must through experience and repeated examination of the drum membrane make his own decision as to the necessity for incision of the tympanic membrane. Relief of pain by adequate sedatives and attention to the nose will frequently abort situations which might seem to require surgery. Progress toward definite accumulation of purulent fluid is often amazingly rapid and only vigilant observation will indicate the train of events. No rules can be laid down, but in general it may be said that the more rapid the progress toward severe though temporary loss of hearing, toward complete loss of all recognizable landmarks, and a definite elevation in temperature, the more certainly is surgical drainage of the tympanic cavity indicated.

Myringotomy, or incision of the drum membrane may well be considered a minor surgical procedure, but it is one which can be performed expertly or with a crudity productive of disastrous results for the patient. Prime essentials are adequate illumination, sufficient anesthesia, not only for the comfort of the patient but for the convenience of the physician, and a proper armamentarium of which the most important constituent is a sharp knife. Of this latter there are many variations; the one shown in Figure 2 has many advantageous features.

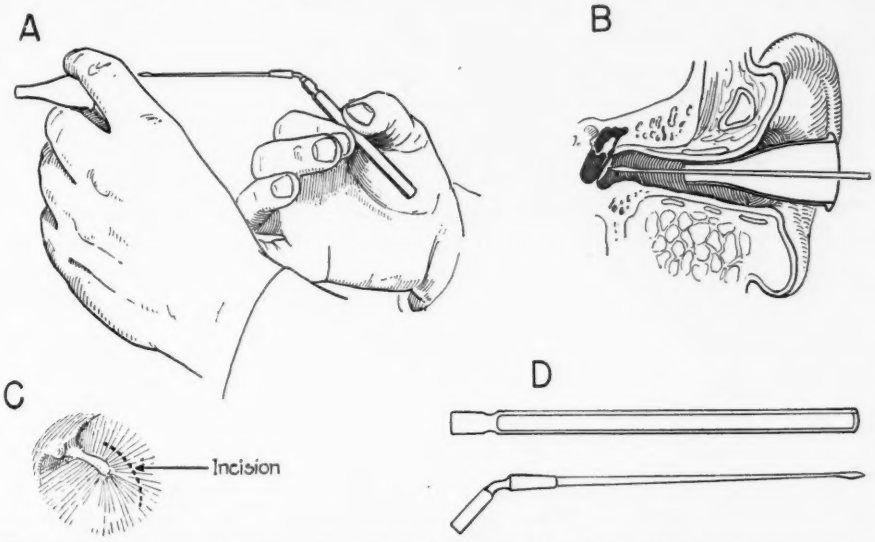

Fig. 2. Essentials in the operation of myringotomy (incision of the tympanic membrane). A, correct method of holding knife and aural speculum. The grasp of the right hand assures a delicate sense of balance and contact with the drum surface. B, relationships of the knife blade, drum membrane and aural speculum. C, approximate line of incision from above downward (left ear). D, a convenient form of knife with friction seating blade which can, when not in use, be inserted within the hollow handle and so be protected from damage. (From Richards' "Otolaryngology in General Practice," Macmillan.)

Equally important is the proper placing of the incision. This should be of adequate length and not in the nature of what is still erroneously called a paracentesis. Such placement is rendered the more difficult because of the often complete absence of all landmarks, and particularly of the otherwise clearly evident line of angulation between the posterior canal wall and the posterior margin of the drum. Inept incision of the former is not only futile in securing adequate middle ear drainage but productive of possibly undesirable complications outside the middle ear. Ideally the incision, carried from above downward, should run about halfway between the line of the handle of the malleus and the

posterior margin of the drum, starting near the superior drum margin and extending in a curve as nearly as possible to the floor of the canal. Further difficulty will at first be encountered in estimating the depth of penetration of the knife point through the drum membrane which, often greatly thickened by the inflammatory process, will offer all varieties of resistance to incision. In the presence of marked bulging and fluid and even air bubbles under considerable pressure, the drum may be so stretched that even the lightest touch will penetrate, whereas it may be so porky and edematous as to require a distinct effort to pierce it. Essential in either case is the avoidance of contact with the inner tympanic wall which harbors structures whose injury is always to be avoided. In general it may be said that penetration of the knife point not more than 1/8 inch beyond the inner drum surface will be quite adequate and will avoid all danger. With descent of the blade the point must be carried slightly inward to conform to the normal inward declination of the drum.

Some form of anesthesia will greatly facilitate the execution of any myringotomy. For children up to the age of 3 years primary induction with ether will prove eminently satisfactory; even in the face of an upper respiratory infection it carries only a minimum risk of pulmonary infection. Its short duration still allows ample time for the incision if necessary, of both drums, recovery is rapid and the after effects are seldom, if ever, of any significance. As a substitute many otologists prefer the use of ethyl chloride sprayed on a small piece of gauze with the admixture of an ample supply of air, though anesthetists all claim an added risk as compared with ether. For older children and adults gas oxygen will prove in general satisfactory, though a tendency to stridor, cyanosis, and head movement are unpleasant features from the standpoint of the surgeon. Both ether and ethyl chloride can be administered by the operator, but gas necessitates an assistant and the transportation of cumbersome apparatus.

For those who, with adults, prefer a local anesthesia, there is available the following mixture:

Cocaine hydrochloride		
Menthol		
Carbolic acid	aa	ʒ ss
Rectified spirits of wine		
Oil of cloves	aa	ʒ ss

This medication is to be dropped in the aural canal and left in contact with the drum for twenty minutes, or a cotton pledget soaked in the solution may be placed in contact with it. While in some ways not so satisfactory, this anesthesia in the hands of those accustomed to using it has proved quite adequate.

Proper incision of the tympanic membrane may be followed by one of several results. In the presence of a thin tense drum, there will often be heard a crackling, snapping sound, with an immediate evident release of turbid fluid which, slightly blood tinged, soon fills the auditory canal. From a prognostic standpoint such a result can be viewed with justifiable hope that a rapid convalescence will ensue with prompt relief of pain and an absence of complications, the possible development of which makes even a simple otitis media an always potentially dangerous condition. In those instances in which incision yields the sensation of cutting through thick edematous tissue, the immediate flow of purulent fluid is quickly obscured by profuse bleeding without the sensation of the release of any intratympanic pressure.

In either case there arises the problem of immediate after-care and proper methods for dealing with the subsequent discharge. A variety of methods have found favor according to the individual preference of the physician. So-called dry treatment involves the insertion into the aural canal of some type of gauze or cotton wick, reaching, if possible, down to the drum surface and designed to act as a capillary drain to promote the best possible drain-

age. Such wicks must be frequently changed as soon as saturated and for this reason make often impossible demands on the physician's time, as patients or parents are usually incapable of caring for this matter personally.

This situation has led to the frequent adoption of the method of irrigating or syringing the aural canal with some bland solution such as boric acid or normal saline. This is best introduced by means of a container elevated above the patient's head, with the fluid flowing through the tubing and out through a glass medicine dropper tip inserted just within the external auditory meatus.

In the opinion of many competent observers no marked superiority lies in either form of after-care, provided that adequate drainage is maintained from the middle ear. Of far greater importance is the accurate appraisal of the subsequent course of the disease, since on this depends the application of the proper surgical therapy in the event that the infection extends beyond the confines of the middle ear to involve the adjacent pneumatic structures known as the mastoid.

ACUTE MASTOIDITIS

As indicating various degrees of progress toward such a complication, certain features of the clinical course must be recognized and understood. In many instances incision of the drum membrane may in a few days be followed by prompt subsidence of all symptoms. Fever and pain will promptly abate, and the discharge, at first profuse, will soon diminish and disappear. Normal hearing will return and clinically a cure is established—the outcome in thousands of cases of acute otitis media. In other instances resolution will take place more gradually, fever will persist for ten days to two weeks, returning to normal with irregular picket-fence swings, pain may not be immediately relieved and poor hearing may persist. In such instances there must always exist the suspicion that the infection has not been confined to the middle ear but may have invaded the pneumatic extensions of the middle ear cavity which in their fine arborizations and subdivisions occupy the mastoid process. The direct contiguity of the lining of the mastoid cells with the mucosa of the middle ear makes such an extension always a clinical possibility. The additional finding of tenderness on pressure over the mastoid and edema or even erythema of the overlying skin and periosteum still further strengthen the suspicion of the existence of acute mastoiditis.

Such early signs of mastoid involvement, are however, no guaranties that surgical intervention will be required. With continued efficient drainage of the middle ear and the development on the part of the patient of adequate bodily defenses against the infection, recovery will frequently take place with no untoward sequelae. The assurance, in the face of persisting fever and discharge, that such a favorable outcome is at least possible, if not probable, is to be sought in repeated careful observations of the tympanic membrane. With slow but steady improvement, changes will be noted in the appearance of the drum which presage recovery. Whereas at the height of the infection all normal landmarks are no longer recognizable and the drum surface is highly distorted, there will occur a gradual reappearance of those features which make up the normal membrane. The surface will begin to flatten and lose its irregularity. The periphery will appear more clean cut and more sharply demarcated from the adjacent canal walls, suggestions of such landmarks as the malleus handle and its short process will be evident, and particularly the site of the perforation, heretofore unrecognizable, will be visible. With continued favorable progress, the edges of the perforation will become more distinct, a valuable indication that the entire mucosa of the middle ear is undergoing the thinning process which is such a pronounced feature of resolution of the infection. Discharge may persist in the face of all these signs, but

with coincident fall in temperature, improvement in hearing and further well being of the patient it is usually safe to delay any surgical attack on the mastoid for at least a reasonable period. How long such a period will be, cannot be specifically stated. At the outset of this type of middle ear infection, the clinical picture may be such as to tempt the physician to conclude that immediate mastoidectomy is indicated. Fever, mastoid tenderness, pain and suggestions of toxemia in the patient's general appearance all may justify the feeling. Nevertheless, in the opinion of most competent otologists a delay of at least a week's time following drum incision, if supplemented with supportive treatment, is frequently not only justifiable but advisable.

Unquestionably in occasional instances, mastoiditis may be considered a surgical emergency, but as a rule there is no necessity for haste and temperate delay during a careful observation of the patient will prove the best policy. Even if resolution as above described does not take place, no essential disadvantage occurs from such delay. In the course of ten days to two weeks it will then be apparent that the desired improvement in the drum is not taking place. There is no sign of returning landmarks, the drum still looks thick and peripherally constricted, the site of perforation is not evident or else is seen to present a nipple of protruding tympanic mucosa, and the discharge is as thick and purulent as ever. Nevertheless, the patient may feel better and suffer no pain; there may be no trace of mastoid tenderness or edema; and fever may be of so low grade a type as to attract but little attention. It is precisely in this situation that mastoid surgery is often clearly indicated. Further hopeful delay will be provocative only of further middle ear drainage with possible permanent hearing defects and eventual implantation of a chronic bone infection most difficult of eradication.

Believing the absence of acute symptoms to signify recovery, the patient and his family are the more surprised to be told that a mastoid operation is necessary. It is the application of just such properly timed surgery that has been so successful in reducing the number of cases of chronic otitis media and in preserving the hearing of thousands of children which would otherwise have been partially or totally lost.

From time to time particularly in the case of infants and young children, less frequently in adults, there will be observed the typical post-aural swelling, erythema, tenderness and sometimes fluctuation which combine to form the textbook picture of acute suppurative mastoiditis. These signs result from a perforation of the mastoid cortex with a resultant escape of pus under the periosteum to produce an inflammatory reaction in the overlying soft tissue. While by no means constituting a true emergency, the indications for surgery are quite obvious. Simple incision and drainage of superficial pus will usually not suffice to cure the associated otitis media and thorough eradication of the underlying and more deeply infected mastoid cells will usually be required. Care must be taken that such post-aural edema and tenderness be not mistaken for a somewhat similar finding due to an infection, diffuse or circumscribed, of the external auditory canal. A careful examination of the canal and drum membrane will usually serve to avoid this confusion.

From the above it will be apparent that the decision as to the advisability and urgency of any drainage of the mastoid process depends first of all on an appraisal of the patient's general condition and the progress with which he succeeds or fails in overcoming the infection, and second, on a thorough understanding of the significance of the various phases exhibited by the drum membrane. Where definite, albeit slow, improvement is clearly evident, it is often good judgment to delay any surgical intervention. When classical signs indicate that the patient, both locally

and systemically, is losing ground, consideration of more radical measures is necessary. No definite time limit can be applied to a given situation and experience and surgical judgment must be the basis for decision.

SINUS THROMBOSIS

During the course of an acute otitis media either before the damage of a complicating mastoiditis or after it, certain symptoms may be present to indicate the development of a complication which may necessitate either more prompt initial surgery or secondary and more radical measures. The basis for this fact lies in the close proximity to the mastoid process of the lateral sinus, the large venous channel which, passing downward and anteriorly from the torcula Herophili, becomes the internal jugular vein. As it traverses the mastoid it may lie in close relationship with infected mastoid cells which, either by direct continuity or through a thrombosis forming in small venous channels in the bone, provoke an inflammatory reaction in this venous channel. This reaction may at first consist of a simple phlebitis of the venous wall which will subside with prompt removal of the overlying infected mastoid cells or interception of the small infected venules leading into the vein. If neglected or unrecognized the process may go on to thrombus formation, either mural or occlusive, with secondary systemic propagation of infection into the blood stream (septicemia or bacteremia) or to isolated parts of the body with metastatic abscess formation (pyemia). It is obvious that such phlebitis or sinus thrombosis demands prompt recognition and usually surgical therapy in order to forestall such potentially serious complications. Details of the many surgical problems arising in connection with sinus surgery are beyond the scope of this paper.

While there is no classical clinical picture of such a situation, lesions of the lateral sinus are commonly manifested by a higher and more irregular type of fever than is consistent with simple mastoiditis, frequently by recurrent chills and, if well established, often by the presence on culture of active organisms in the blood stream. Since such a systemic complication is most often due to the Streptococcus hemolyticus, there is almost certain to be present a slowly progressive anemia, the recognition of which is important both diagnostically and therapeutically, small and frequent transfusions being an important part of the treatment.

It is essential in the face of the above symptoms not to lose sight of the possibility of other conditions which in the presence of an acute otitis media may simulate sinus thrombosis. Such are acute cervical adenitis, pyelitis, acute nephritis, early erysipelas and a central pneumonia, undetectable by ordinary physical examination. For this reason, hasty surgical attack is to be withheld until the presence of a sinus complication is as assured as all diagnostic means can achieve, lest inappropriate operative measures serve only to complicate the situation. To this extent the condition of sinus thrombosis is not an emergency, and the necessary time to make use of customary diagnostic procedures such as a blood culture, chest *x*-ray, and complete urine examination will be more than justified and will in no way jeopardize the patient's chances of recovery.

MENINGITIS

More nearly constituting a surgical emergency in otitis media is the complication of meningitis. Since the middle ear, mastoid antrum, and certain mastoid cells lie in close proximity to the dura of the middle fossa and since the intervening thin plates of bone may be readily destroyed by infection, meningeal irritation or actual subarachnoid infection may follow otitic suppuration. Even in the absence of actual bone destruction meningeal infections may arise from the propagation of aural infection by way of small vascular pathways leading to the

meninges. Such a complication not infrequently makes its appearance at the very outset of an acute middle ear inflammation almost before the clinical picture of the latter is definitely established. At other times meningitis may be associated with a definite mastoiditis either before this has been cared for surgically or as a postoperative complication.

Such meningeal infection has in recent years been the subject of most intensive study by otologists who have sought in every possible way to discover early diagnostic signs which would point the way to the development of otitic meningitis before it becomes full-blown. Study of the chemistry of the spinal fluid and of the blood is playing an important part in this endeavor to appreciate the significance of apparently minor disturbances in the patient's condition are being found to be significant warnings. Headache, photophobia, vomiting, or undue irritability during the course of an acute otitis media or mastoiditis would at once arouse the suspicion of the possibility of meningeal complications and warrant the application of all recognized methods of diagnosis. Given the presumable existence of a definite meningeal infection, prompt surgical exposure of the dura in the region of the middle ear and mastoid cells is the accepted mode of attack, supplemented by all other possible means of combating this serious complication.

In this connection, mention should be made of the present enthusiasm, particularly in otitic meningitis, for the use of sulfanilamide. Until the advent of this drug, this condition, in spite of every known form of therapy, carried a mortality rate of between 90 and 95 per cent. To date the prompt institution of surgical drainage in combination with sulfanilamide therapy has served to reduce the figure to an astounding extent and the literature is replete with reports of recovery in cases which would formerly have been considered utterly hopeless. Of use particularly in meningeal infections, sulfanilamide has also been employed extensively in simple acute otitis media in the hope of avoiding mastoiditis and in mastoiditis with a view to localizing the process and preventing the development of such complications as have been above described. At present there is still some controversy as to the value of the drug in this field, considering the possibility of its masking valuable signs of the extent of a mastoid infection and the possible disadvantage and even danger in its use. Further clinical experience will be necessary before final conclusions can be drawn.

The above consideration of otitis media from the standpoint of the application, early or delayed, or appropriate surgical therapy has necessarily omitted much that is pertinent to the discussion or that would seem essential from the viewpoint of the otologist. For the practicing physician who will from time to time encounter the diseases it is chiefly essential, (1) that he be able by a competent examination to make the diagnosis of an acute otitis media; (2) that he comprehend the recognized indications for incision of the drum and the technique of its execution; (3) that he be able to appraise the clinical course and at least sense that it is or is not proceeding satisfactorily; and, (4) that he be alert to secure competent help in the event that his observations indicate impending and possibly serious complications.

PERITONSILLAR ABSCESS

A peritonsillar abscess or "quinsy sore throat" is frequently the occasion for surgical drainage, first, to relieve the severe pain which is so pronounced a feature and secondly, to forestall the development of respiratory obstruction which is at times a complicating factor. Where the latter situation is clearly evident, drainage becomes in a sense urgent and hence this might properly be said to constitute an emergency. In by far the greatest number of instances, however, classical signs of such an abscess

are plainly evident long before respiratory obstruction is a serious consideration and the institution of drainage will usually prevent its development.

undergoing apparent resolution, appears from the patient's point of view to recur but now only on one side. The pain attending this return of the sore throat is, how-

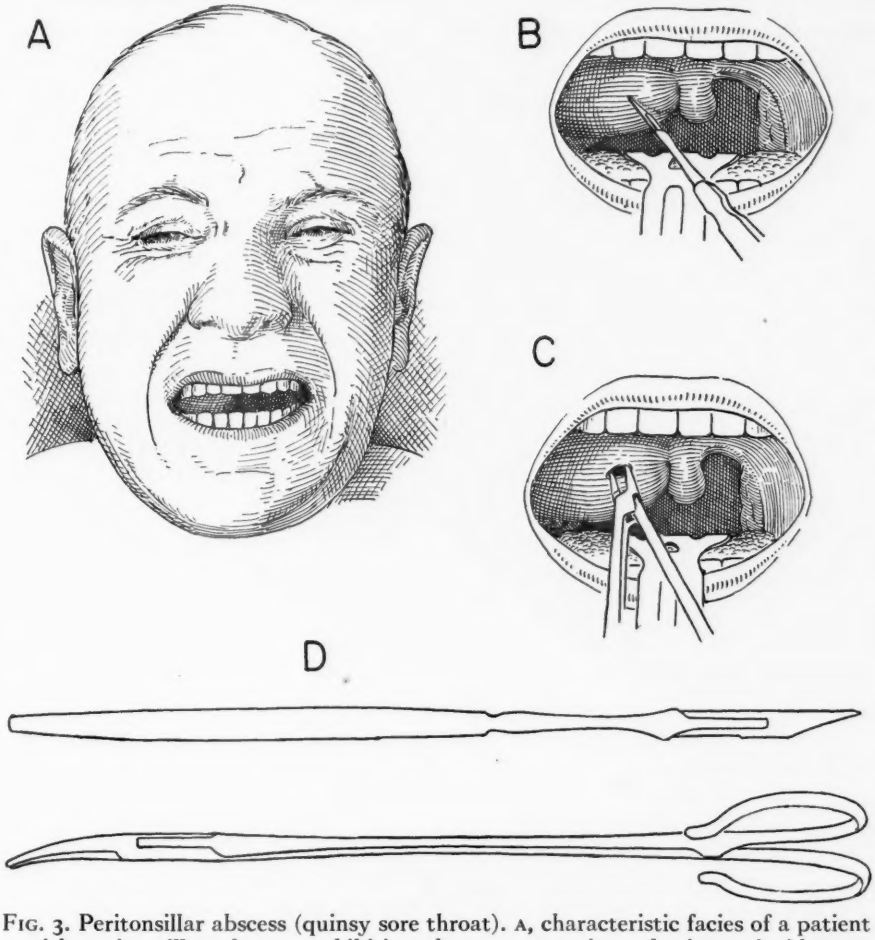

Fig. 3. Peritonsillar abscess (quinsy sore throat). A, characteristic facies of a patient with peritonsillar abscess, exhibiting the extreme pain and trismus incident to attempts to open the mouth. With the exception of perialveolar abscess, few other acute laryngological infections produce this appearance. B, incision of the abscess. After cocainization, the sharp knife point is centered at the area of maximum tenderness, induration and blanching to a depth of approximately ½ to ¾ inch. This will commonly be followed by a trickle of pus. C, insertion of the hemostat and spreading of the edges of the incision. D, the knife and hemostat suitable for incision and drainage of a peritonsillar abscess. (From Richards' "Otolaryngology in General Practice," Macmillan.)

A peritonsillar abscess in the true sense of the word is an accumulation of pus in the potential tissue space which is bounded superiorly by the superior pole of the tonsil, anteriorly by the soft palate and anterior tonsillar pillar and posteriorly by the superior constrictor muscle of the pharynx. The development of such an abscess is commonly preceded by an acute tonsillitis, usually bilateral, which, after

ever, much greater than with the original tonsillitis. The condition is almost universally confined to patients over 12 years of age. The condition said to be a "peritonsillar abscess" in a child will usually be found on closer examination to represent infections or collections of pus either back of the tonsillar bed just outside the pharyngeal fascia or in the lateral retropharyngeal space where the resultant

swelling tends to push the tonsil forward. In neither instance will pus be found in the supratonsillar space and the classical findings described below will not be evident.

Of rapid development and of almost pathognomonic significance in peritonsillar abscess is the sign of trismus, provoking in a few hours the greatest difficulty for the patient in opening his mouth. Frequently the dental margins cannot be separated more than 1 or 2 cm., a situation resulting from an infiltration of the pterygoid muscles with attendant spasm and fixation. Tetanus and perialveolar abscess are the only other two conditions which provoke like difficulty. Fever is seldom a prominent symptom, temperature ranging usually below 100 degrees. In contradistinction to neck infections which are localized externally to the pharyngeal fascia, there is usually no external swelling of the neck, and often practically no tenderness.

The patient presents a characteristic appearance. (Fig. 3.) Swallowing is so painful that saliva is allowed to drool from the lips and all food and liquids are refused. The voice, as a result of the palatal edema, has a distinct nasal quality but laryngeal involvement with hoarseness is rare.

Examination of the throat is rendered extremely difficult because of the inability of the patient to open his mouth although gentle insinuation of a thin bladed tongue depressor will usually permit a fairly satisfactory view of the site of the abscess. The entire region of the involved tonsil is the site of a marked edema of the soft tissues. The demarcation between the tonsil and the anterior pillar is obliterated and the soft palate up to or even beyond the midline is swollen and firy red in color. The extension of this edema to the uvula often results in a characteristic displacement of this swollen structure to the opposite side. If space between the teeth permits, palpation with the index finger or a cotton tipped probe will, in a well advanced abscess, reveal a certain point of maximum tension and blanching on pressure, the location of which is important in selecting the site for drainage.

While the development of such a peritonsillar abscess is rapid, there is nevertheless a developmental period when, in spite of obvious signs pointing to the existence of such an abscess, attempts at drainage are fraught with risk of failure. During the period before the assurance of definite localization it is usually wise to delay incision and make the patient comfortable by the administration of adequate sedatives and by utilization of such local measures as hot saline or glucose irrigations and external heat. Within twenty-four to forty-eight hours such treatment will usually result in the appearance of signs of localization, chief of which is the recognition on palpation of a point of maximum tenderness, resistance or even vague fluctuation. This will commonly be located in the soft palate about midway between the dental line and the uvula and about a centimeter above the normal location of the top of the tonsil.

Such delay, perhaps to the temporary disappointment of the patient, will spare him the agonizing discomfort of abortive attempts to drain an abscess not yet present. The procedure is not only provocative of immediate severe pain, but necessitates a secondary incision at a later and more appropriate date, oftimes by a second physician whose immediate success will contrast most unfavorably in the patient's mind with the failure of his predecessor.

Incision and Drainage. Any form of general anesthesia is to be avoided. The dangers of complete narcosis in the presence of marked trismus are clearly evident, and the policy of some operators of excellent reputation of removing the tonsils at the same time would seem to carry an unnecessary risk. It is true that ideal local anesthesia is difficult to secure, owing to the intense edema of the palatal tissues, but the application of a swab soaked in 10 per cent cocaine to the region of the proposed incision will prove reasonably satisfactory for all but the final stretching

of the wound edges. Incision is best begun by the insertion at the point of maximum tension, fulness, bulging or blanching of the blade of a long handled sharp knife. (Fig. 3.) The knife point is carefully advanced toward the presumed center of the abscess for a distance of about 1 to 1.5 cm. and then withdrawn. With the use of cocaine as above described this initial incision will prove surprisingly painless. If the abscess cavity has been entered the withdrawal of the knife blade will be promptly followed by a thin trickle of pus from the point of the incision. If this favorable sign does not appear the abscess may not as yet have localized, premature incision may have been undertaken and further attempts to enlarge the incision should be avoided till a later date. It is possible that the abscess, though present, has not been reached. A slightly deeper penetration at the same point may yield pus, but promiscuous stabbing here and there will serve only to hurt the patient and possibly to disseminate infection into uninfected tissue planes with disastrous results. Given a properly timed incision and definite clinical signs of an abscess, preliminary incision will usually "strike oil." This result having been achieved, it remains to enlarge this drainage tract by inserting into it the closed blades of a long handled hemostat. With the blades inserted within the abscess cavity, a single opening will serve to establish an adequate wound of exit which will seldom require further enlargement. (Fig. 3.) This second step in drainage is admittedly painful and no form of local anesthesia will entirely eliminate this momentary discomfort, but it is so regularly followed by marked relief in an astoundingly short time as to more than justify this method. Within a half hour the patient will frequently experience marked relief and under continued administration of hot throat irrigations the entire inflammatory process rapidly subsides. It is seldom necessary to undertake any secondary incision, though there is occasionally a tendency for the wound edges to seal together and to require gentle separation. Often at the end of a week it is difficult to observe any sign of the previously severe inflammatory reaction.

Subsequent attacks of peritonsillar abscess are best avoided by complete tonsilectomy undertaken during an interval of complete freedom from local inflammation. Such a tonsillectomy will often prove more than ordinarily difficult because of adhesions resulting from the previous peritonsillar infection and great care must be taken in the dissection to avoid tearing the peritonsillar tissues and particularly the leaving of any tonsillar remnant at the superior pole. Such a remnant may later form an ideal spot for recurrent inflammation which may closely simulate a peritonsillar abscess.

Untreated or undrained, a peritonsillar abscess may eventually rupture spontaneously without untoward results. To await this outcome in preference to surgical incision and drainage is to subject the patient to unnecessarily prolonged discomfort as well as to risk aspiration of the contents of the abscess with possible subsequent inhalatory pneumonia.

RETROPHARYNGEAL ABSCESS

It has been said by prominent pediatricians that a retropharyngeal abscess is more often inaccurately diagnosed than any other condition in infancy. This situation arises primarily from the fact that such an abscess may, because of its protean manifestations, so simulate a number of totally unrelated diseases as to create frequent difficulties in diagnosis.

Pathologically, retropharyngeal abscess develops as an enlargement of one of the several pharyngeal lymph nodes which lie beneath the mucosa of the pharynx anterior to the cervical spine. Such glands are usually located to the left or right of the midline at varying levels, so high as to be hidden behind the soft palate or so low as to be retrolaryngeal or even retroesophageal. With progression of pyogenic infection which reaches these glands from some

primary focus in the nasopharynx, the glands begin to undergo liquefaction and to break down into a frank abscess.

As such an abscess enlarges, it may, depending on its location, cause a wide variety of symptoms. A relatively high abscess will produce obstruction to nasal breathing and may readily be mistaken for an enlarged adenoid. If occupying the region of the nasopharynx, such a swelling of the posterior pharyngeal wall will provoke difficulty in swallowing more often due to mechanical interference than to pain. Stiffness of the neck, so frequently associated with retropharyngeal abscess may be confused with such orthopedic conditions as cervical spine disease or torticollis, or may be of such severity as to give rise to the suspicion of the presence of meningitis.

The picture of some degree of surgical urgency may be created by an abscess which, lying directly posterior to the larynx, either presses against the latter directly or so overhangs it as partially to block the glottic entrance. The resultant dyspnea may not only be severe, but may be such as to suggest its source to be in the larynx itself and thus to provoke measures for its relief which fail to take into consideration the true nature of the difficulty. Thus tracheotomy for such a form of laryngeal obstruction is by no means as suitable as drainage of the retropharyngeal abscess which is the basic cause for the laryngeal symptoms.

Less obviously related symptoms such as sore throat, cough, unexplained fever and even convulsions in infants and younger children may all be due to a retropharyngeal abscess, the existence of which may not be suspected either from the history or the conventional examination of the throat.

The best method of avoiding this diagnostic dilemna is the constant retention in the mind of the examining physician that a retropharyngeal abscess in this age group from birth to 3 years may be responsible for any of the aforementioned symptoms. Other causes will often enough be present, but if an abscess is ruled out by inspection, palpation and *x*-ray, few diagnostic errors will be made.

Proper examination of a retropharyngeal abscess is not the simple matter that one might at first consider it. The forceful depression of a prominent tongue will not only frequently fail to reveal an abscess that lies either above or below the direct line of vision, but has been known on more than one occasion to provoke either temporary cessation of respiration or even to initiate a rapidly fatal apnea. By the same token the forceful opening of the mouth with a mouth gag is strongly contraindicated since it is capable of leading to equally disastrous results. Far safer and more informative is the introduction into the mouth of the left index finger with the physician standing at the patient's head and facing the patient's feet. In this manner the finger may readily be swept over the entire posterior pharyngeal wall from the level of the soft palate to a point well below the larynx. The involuntary gag reflex will adequately protect the finger from injury in older children. By this means the characteristic unilateral protrusion and the tense, smooth and elastic wall of the abscess will be readily recognized after one or two encounters with this condition. Such palpation will often prove far more informative than inspection, which, if the abscess is beyond the line of vision, will frequently be entirely negative.

Supplementing physical examination and available even before any local inspection is a lateral *x*-ray of the cervical spine, which will usually show the presence of a retropharyngeal abscess as a marked forward deviation of the soft tissue line of the pharynx or upper esophagus. Whenever possible, such Roentgen ray examination should never be omitted when retropharyngeal examination is under consideration.

Incision and drainage of a retropharyngeal abscess should almost always be undertaken without any anesthesia. Local anesthesia in infants and younger children

is fraught with definite danger of toxic absorption, and general anesthesia is contraindicated because of the risk of possible respiratory obstruction in the presence of any retropharyngeal swelling. It was formerly a common custom to incise the abscess, with the patient in an upright position, by palpating the anterior surface of the abscess with the left index finger and then blindly passing the point of a long handled knife along this finger and penetrating the wall of the abscess. The patient's position was

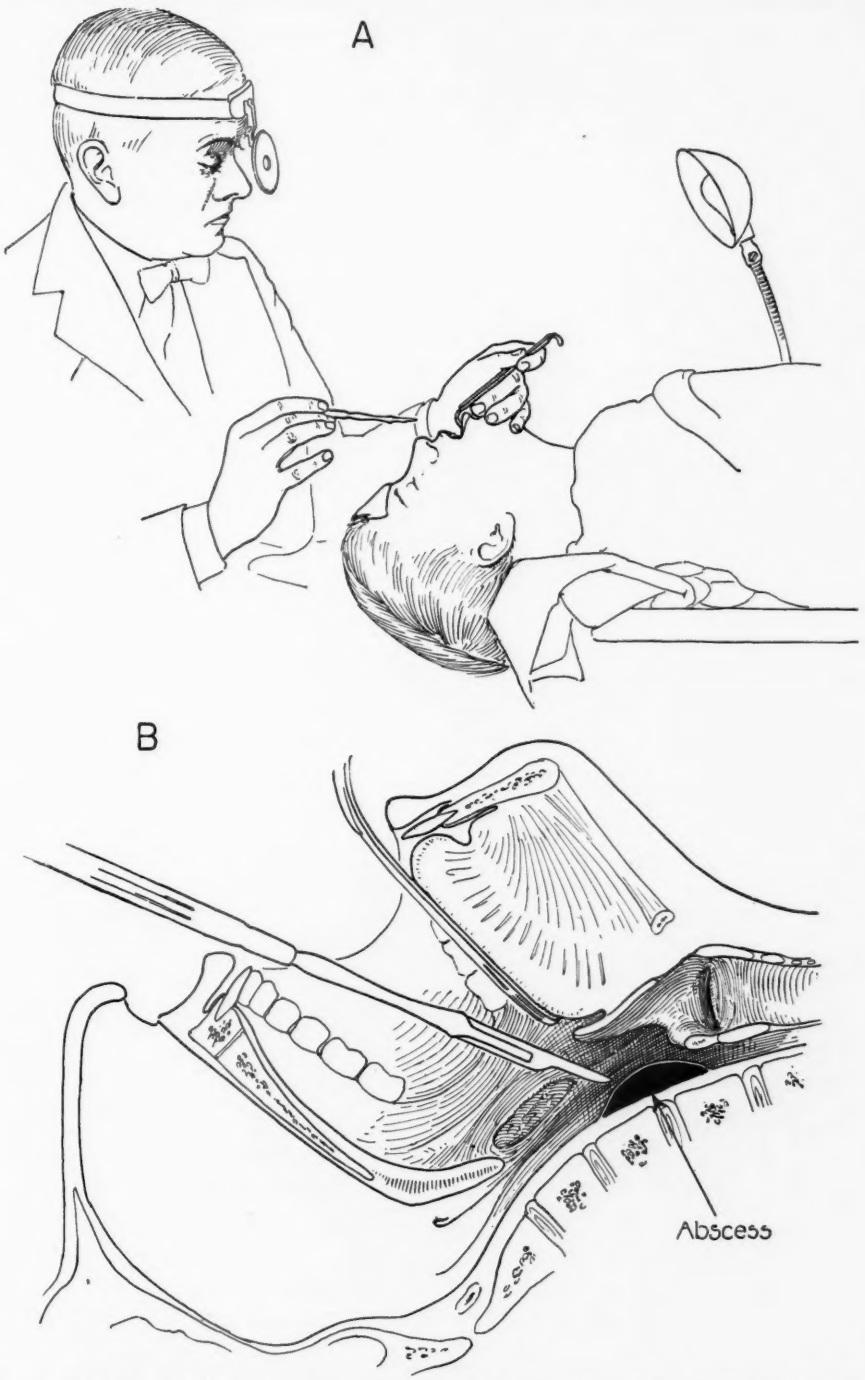

Fig. 4. Incision and drainage of retropharyngeal abscess. A, positional relationship of operator and patient. B, detail of incision of abscess. (From Richards' "Otolaryngology in General Practice," Macmillan.)

then immediately reversed and the head allowed to hang down to permit the evacuated pus to run out of the mouth.

This procedure obviously lacking all the advantages of direct visionary control, carried the risk of inaccurate placement of the incision with possible damage to adjacent structures in the pharynx. With many operators it has been supplanted by the method illustrated in Figure 4. The patient lies on his back, properly restrained by wrapping in a blanket, and the physician is seated at the head, viewing the throat by light reflected to the pharyngeal wall from a head mirror. A simple angulated tongue depressor serves to *elevate* the tongue, thus exposing and illuminating the entire posterior pharyngeal region and site of the abscess. A suitable knife blade is then carried directly to the point of maximum fluctuation in full view of the operator. As in the case of peritonsillar abscess the proper placement of the incision will be at once manifest by the appearance of a trickle of pus following withdrawal of the knife blade. A small suction tube is then employed slowly to evacuate the abscess cavity and at the same time to prevent the possible access of pus to the lower airway. As a final assurance of good drainage, the edges of the incision are widely separated by inserting between them the closed blades of a hemostat and by opening them in situ. The usually small amount of bleeding incident to the incision will cause no concern, but if more than ordinarily profuse, may be controlled by temporary insertion of a gauze tampon within the abscess cavity. A sudden profuse hemorrhage would on the rarest occasion give all too tardy warning that not an abscess but an aneurysm had been incised.

Convalescence is usually rapid and uneventful. No special after-care is required and necessity for any secondary incision is quite rare. The associated unilateral cervical adenitis so often seen in conjunction with retropharyngeal abscess will usually subside but may at times require independent and external incision.

The single complication which must ever be borne in mind is secondary hemorrhage. This originates not in the abscess cavity per se, but rather as a result of deeper extension of the original infection in the retropharyngeal tissues to the point where there takes place an erosion of the internal carotid artery. As a measure of self protection, the vessel then builds up a pseudoaneurysm and a laminated clot which periodically weakens and permits a sudden flow of blood from the pharyngeal wound. Such a sudden hemorrhage may recur at intervals on several occasions. Its first appearance, however, is a clear indication to the physician of impending catastrophe and no time should be lost in ligating the carotid artery on the appropriate side. It is preferable to tie the common carotid, since this procedure still permits some arterial blood to reach the brain by retrograde flow of collateral circulation from the opposite side via the external carotid. Any subsequent bleeding, indicating that common carotid ligature is not adequate, should be immediately dealt with by ligature of the internal carotid as the only assured means of forestalling a subsequent and possibly fatal hemorrhage. Such ligation for this unusual complication may well be classed as a surgical emergency.

Tracheotomy, properly speaking, should seldom if ever be required in the treatment of retropharyngeal abscess even in the face of threatened respiratory obstruction, since prompt evacuation of the abscess will almost always be quite adequate to restore a patent airway. It is conceivable that on rare occasions impending asphyxia may so threaten the patient's life that an emergency tracheotomy will be necessitated by the lack of time available for investigation and drainage of the abscess itself. Under these circumstances a retropharyngeal abscess would occupy a prominent position in any list of surgical emergencies.

TRACHEOTOMY

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TRACHEOTOMY, one of the oldest operations in surgery is today done badly more often than any other surgical procedure. The faults are closely related to surgical literature. One of the greatest literary faults is the perpetuation of the traditional division of the procedures into high tracheotomy and low tracheotomy with reference solely to whether it is done above or below the isthmus of the thyroid gland. This is a relic of the time when all conscientious surgeons regarded the thyroid gland as a *noli me tangere*. Asepsis and other improvements in technique brought the thyroid gland into the field of everyday surgery but the old tradition was handed down from textbook to textbook without recognition of the utter absurdity of the surgeon being influenced by the location of the inconsequential isthmus.[1,2]

The worst feature of this absurd classification was the faulty teaching that went with it in all the textbooks. As a consequence the medical graduate had in mind that the high operation was easy, the low operation difficult. The result of these false conceptions was that the occasional operator in an emergency did a high and hasty operation which usually meant a technically bad operation, even though the life of the patient was saved by it.[2] The thyroid and cricoid cartilages were often cut and a series of disastrous complications usually followed. So great a surgeon as Billroth made a statement to the effect that tracheotomy in some cases is easy, in others it may be one of the most difficult procedures in surgery. The only conceivable reason for such a misconception is that he was thinking of a low operation done in a deep wound through a short skin incision. With a long median incision giving access to the whole median front of the neck no experienced surgeon has any difficulty in finding and incising the trachea through the second and third rings.

The faults of the literature are not yet wholly eradicated.

INDICATIONS

The chief indication is to prevent asphyxia. This indication arises most frequently because of obstruction of the airway somewhere between the pharynx and the main bronchi. As a clinical fact the obstruction usually occurs in the region of the larynx, but we see also many cases of endotracheal and peritracheal disease in which asphyxia is certain unless tracheotomy is done and proper cannulae reaching below the obstruction are fitted. Air can be efficiently piped down to either or both of the main bronchi.

Obstructive laryngeal dyspnea, as a rule, is an indication for tracheotomy. Though it may be said the urgency of the indication is in direct proportion to the degree of dyspnea, yet if this indication is present at all tracheotomy had better be done at once. Postponing it when signs of this form of obstruction are present is justified only when there is good reason to expect the obstruction will soon subside. Even under such circumstances postponement is dangerous unless the patient is in charge of a trained nurse experienced in tracheotomic cases and a competent surgeon is within a few minutes distance. The cardinal signs of obstructive laryngeal dyspnea are, indrawing at (*a*) the suprasternal notch, (*b*) around the median end of the clavicles,

(*c*) in the intercostal spaces, and (*d*) at the epigastrium.[13] The most marked and most important of these is indrawing at the

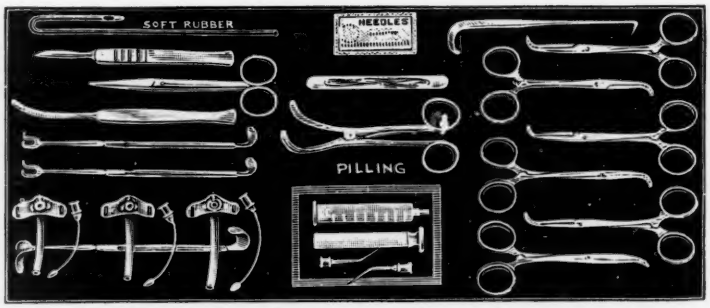

FIG. 1. Instruments that should be available for tracheotomy. Makeshifts will do, but good surgery requires adequate equipment.[6]

suprasternal notch, often called the guttural fossa. This alone is enough to warrant tracheotomy, but its absence should not be construed negatively until a fossa-filling tumor has been excluded. This is done by palpation. Indrawing at the epigastrium is almost always present in children and is quite significant. The cardinal signs enumerated above are not present in cardiac, asthmatic, pneumonic or any kind of dyspnea other than that due to obstruction of the larynx or cervical trachea, hence they are diagnostic of a condition relievable by tracheotomy. Obstruction below this point may also call for tracheotomy, as for example when bronchoscopy has revealed an obstruction of the trachea or main bronchi by an endobronchial, murobronchial or peribronchial tumor or other lesion. Such lesions, invasive or compressive, call for tracheotomy so that air may, by suitably fitted cannulae, be piped down into either or both main bronchi.

Apart from dyspnea, tracheotomy may be indicated for *aspiration* in cases of flooding of the tracheobronchial tree by fluid threatening "drowning of the patient in his own secretions."[6] This applies only to children under two years of age and in them only in conditions that require frequent catheter aspirations (every few hours) by the nurse, for example, acute pulmonary abscess, acute laryngotracheobronchitis. In all other cases in children, and in all cases in adults, peroral bronchoscopic aspirations have obviated the necessity for tracheotomy for aspiration. In the early days of bronchoscopy tracheotomy was done for the introduction of the bronchoscope. Improvements in instruments and in the technique of peroral introduction of the bronchoscope have entirely obviated the necessity for tracheotomy for this purpose, even in the newborn.

In the absence of dyspnea tracheotomy may be indicated as a preliminary to operations such as laryngectomy and pharyngectomy.

CONTRAINDICATIONS

When tracheotomy is indicated to prevent asphyxia there are no contraindications worthy of a moment's consideration. In other conditions it is contraindicated if bronchoscopy (always peroral) will serve the same purpose.

OBJECTIVE

Broadly speaking tracheotomy consists in a long median incision through all soft tissues overlying the cervical trachea, which is incised through the second and third rings. Through this incision a cannula for breathing is inserted.

In well-equipped hospitals tracheotomy has been largely removed from the emergency class by bronchoscopy. With a bronchoscope in situ the patient's breathing is easy and tracheotomy may proceed in an orderly way. The same end may be accomplished by the insertion of Mosher's intubational life saver of proper size. In hospitals less well-equipped emergency

tracheotomy will still be required as for centuries past. For these reasons consideration of both emergency and orderly tracheotomy are called for here.

ORDERLY TRACHEOTOMY

Instruments. An adequate equipment is as follows (Fig. 1):

Headlight.

Scalpels.

Curved, probe-pointed bistoury.

Tenaculum, special Chevalier Jackson model.

Two retractors.

Trousseau dilator.

Six hemostats (special Chevalier Jackson model preferable).

Scissors (dissecting).

Full curved needles, very small for suture ligatures.

Full curved needles (or clamps) for the skin.

Needle holder.

Suture material (or clamps).

Hypodermic syringe for local anesthesia with bent reinforced needle (special Chevalier Jackson model preferable).

No. 1 plain catgut ligatures.

Linen tape.

Gauze sponges.

Soft rubber catheter (10 F.) for aspiration.

Aspirator, preferably electrically operated.

Oxygen tank.

Tracheal cannula. (Fig. 8.) Size number 5 is suitable for adults, 4 for adolescents, 2 and 3 for children, 1 for infants. Duplicate (exact) will be needed in the after care.

Preparation of the Patient. As the operation is done under local anesthesia *psychic preparation* of the patient is important. He should be assured that the operation is not a serious one, that he will feel no pain and little discomfort; and especially he should be told that the operation will not take long, usually only a few minutes. It is well also to mention the fact that he may at times have his breath shut off; but that you know when this happens and you will not keep it shut off too long. This psychic preparation along with proper local anesthesia will entirely obviate the necessity for resort to general anesthesia, which in dyspneic cases would needlessly introduce an element of great danger.

Local preparation need be no more than shaving in the ordinary way. The skin is sterilized on the table.

Position of the Patient. The best position is that shown in Figure 2.

Enumeration of Steps. (1) Preparation of the skin; (2) local anesthesia; (3) incision (hemostats applied as necessary); (4) dry dissection down to larynx and trachea; (5) disposition of the isthmus of the thyroid gland; (6) ligation of vessels; (7) tracheal fixation; (8) incision of trachea; (9) spreading of the tracheal incision; (10) insertion of the tracheotomic cannula; (11) closure of the incision; (12) dressing and drainage.

Step 1. Preparation of the skin. The surgeon may use his preferred method but there is probably nothing better than the usual manner with tincture of iodine followed by alcohol.

Step 2. Local anesthesia. Novocaine solution of standard strength is withdrawn from ampules directly into the hypodermic syringe. First the midline is injected from the hyoid bone to the suprasternal notch; then the deeper tissues of the midline. There is no need of going far laterally because flaps are not to be dissected up. Usually there is no need of any injection after starting. Instilling cocaine into the trachea is inadvisable; it seems better to allow the cough to clear the trachea and bronchi as soon as the trachea is opened.

Step 3. The *initial incision* in the midline from Adam's apple to the suprasternal notch passes through the skin and superficial fascia. Care is taken in the upper part of the incision to avoid cutting the external perichondrium of the laryngeal cartilages which are usually quite close to the skin. Integumentary vessels are clamped if necessary.

Step 4. Dry dissection. No flaps are dissected up. The incision is deepened in the

midline down to the thyroid, cricoid and tracheal cartilages, care being taken not to injure the external perichondrium, and not to lay it bare except in the midline. The larynx and trachea should not be skeletonized. As in any orderly operation a dry wound should be maintained. There are no large arteries in the midline of the neck, but rather large veins may be encountered. They should be caught and cut off squarely between two hemostats. Nicks, slanted cuts or torn walls are likely to spring a leak later during cough.

Step 5. Disposal of the thyroid isthmus. The isthmus or even the thyroid gland must not be allowed to interfere with a properly placed incision of the trachea (see Step 8). Usually the most that will be necessary is to drag the isthmus upward or downward; but if this is not sufficient, the isthmus should be divided by a vertical median cut. If the cut ends ooze blood each end is quickly closed by a continuous overhand suture. If the isthmus is drawn upward or downward the direction of displacement must be remembered for finding the tracheal slit at the first few dressings.

Step 6. Ligation. Preparatory to the tracheal incision all hemostats must be taken off and a dry wound assured by ligature or torsion. Even slight oozing will result in a spray of blood droplets at each cough after the trachea is incised.

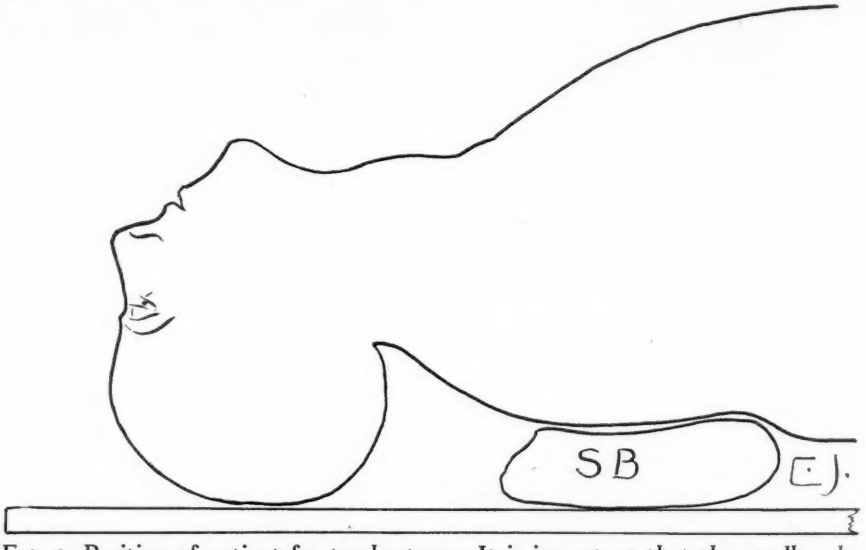

Fig. 2. Position of patient for tracheotomy. It is important that the sandbag be under the shoulders rather than the neck, in order to make the neck more prominent. If this position increases dyspnea, the head should be supported by the nurse, who sits on a stool at the head of the table. Her chief duty is to prevent the head from rotating, which would distort the cervical anatomy. The nose must point to the zenith.[8] (From "The Larynx and Its Diseases" by Jackson and Jackson, published by Saunders.)

Step 7. Tracheal fixation. For a precise incision the trachea is first fixed with the tenaculum. As a rule the hook is passed through the interannular membrane at the lower border of the second ring, in the midline. With the hook under, not sticking in, the second ring, the trachea is lifted and thus fixed; its identity is also thus verified.

Step 8. Tracheal incision. The trachea is incised in the midline caudad from the hook of the tenaculum through the third, fourth and fifth rings. Caution is necessary to avoid incising the tracheo-esophageal party wall. The tracheal rings are really horseshoe-shaped because they are incomplete posteriorly. The membranous posterior wall is especially likely to be cut in children because of the small diameter of the trachea and especially because this small diameter is still further reduced by the mounding forward of the posterior wall

during cough. (Fig. 7.)[19] In adults the posterior wall does not mound forward much because of greater rigidity of the tracheal cartilages, but the accidental puncture into the esophagus is especially likely to happen from the plunging of the knife that has been pressed upon in order to cut through the partially ossified rings. Both these accidents are avoided by guarding the knife with the finger. (Fig. 6.) If preferred, only one ring may be cut with the scalpel and the others then cut with the probe-pointed, curved bistoury.

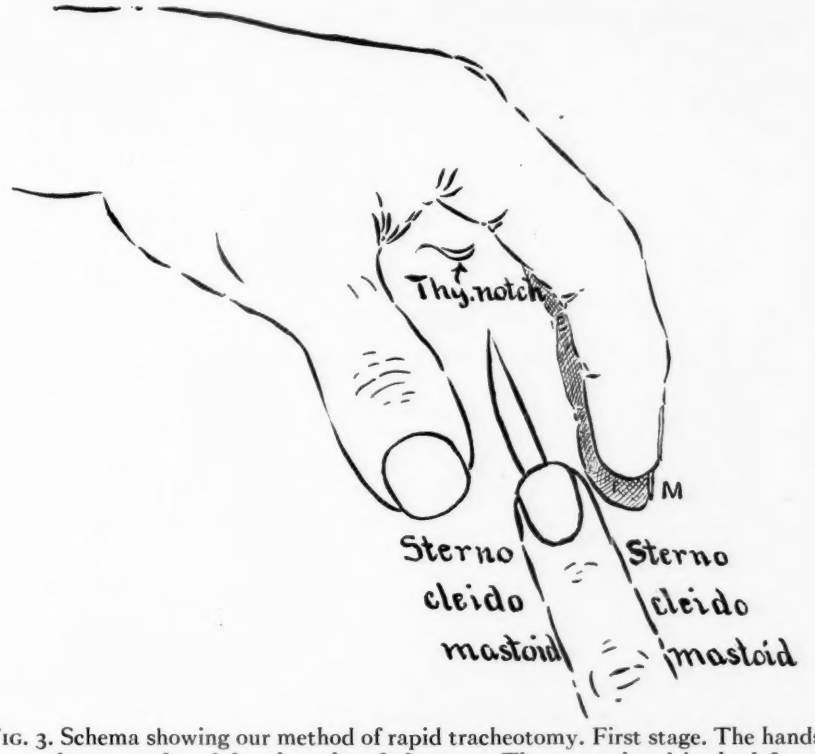

Fig. 3. Schema showing our method of rapid tracheotomy. First stage. The hands are drawn ungloved for the sake of clearness. The upper hand is the left, of which the middle finger (M) and the thumb are used to repress the sterno-cleidomastoid muscles, the finger and thumb being close to the trachea in order to press backward out of the way the carotid arteries and the jugular vein. This throws the trachea forward into prominence, and one deep slashing cut will incise all of the superficial tissues. Full length and depth of this primary incision are necessary to permit finger dissection down to the trachea. (From "The Larynx and Its Diseases" by Jackson and Jackson, published by Saunders.)

Step 9. *Spreading the tracheal incision.* Though there may be a hiss of air as the trachea is incised, the edges of the incision usually approximate so tightly that little air passes. The Trousseau dilator is inserted and the wound spread. Almost always there is a clot of mucopus expelled. If the dyspnea has been considerable the patient takes a deep breath that ends in a sigh of relief. A child worn out by a prolonged fight for air may fall asleep.

Step 10. *Insertion of the cannula.* To make sure the cannula enters the trachea the piloted distal end must be seen to pass in through the tracheal incision. The pilot is usually blown out by the tussive blast; if not, it should be quickly removed. The shield of the cannula, if the tube is of proper length, should stand out a little from the level of the skin.

Step 11. *Closure of the wound.* This may be done either with interrupted sutures or with clamps; but the most important thing is that the wound must not be closed completely, that is not close up to the

cannula. It is better to close only a short part of the upper and lower ends of the incision. (For reasons see *Pitfalls.*)

Step 12. *Dressing and drainage.* With the signs of dyspnea and in the quick but gentle wiping away of the coughed out secretions before they are inspirated into the cannula.

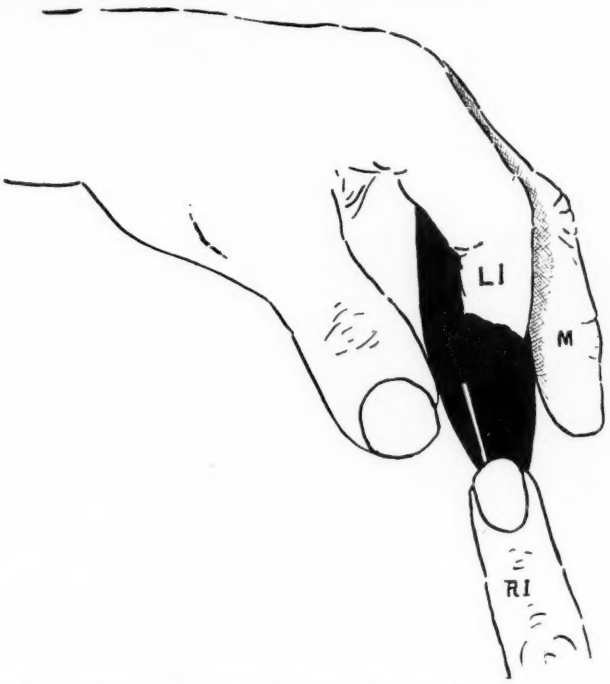

FIG. 4. Second stage of rapid tracheotomy. The fingers are shown ungloved as in Figure 3. In operating, the whole wound is full of blood and the rings of the trachea are felt with the left index finger (LI) which is then moved slightly to the patient's left, while the knife is slid down along the left index to exactly the middle tracheal line when the trachea is incised. If any difficulty is encountered in feeling the trachea the index finger should locate the thyroid cartilage and then burrow on downward onto the trachea, which of course is continuous. Incision is then made in the tracheal rings, preferably below the second ring. (From "The Larynx and Its Diseases" by Jackson and Jackson, published by Saunders.)

an open wound no drainage is necessary. A pad made of six or more layers of folded gauze is split halfway so as to go down astride the cannula back of the shield. Strips or small pieces of gauze are to be avoided because of the danger of an end getting into the trachea or cannula.

AFTER-CARE

At the top of the order sheet is written: "Opiates or atropine should not be given this patient."[9,10] The patient is put to bed with the usual postoperative nursing attention. If the nurse has not had good tracheotomic training she must be instructed in

Dehydration must be avoided. As no nauseating anesthetic or sedative has been given the patient may begin swallowing liquid food at any time. It is exceedingly rare that a feeding tube is required, but there is no contraindication to using it. The room should be well ventilated. In summer this will insure sufficient humidity in most climates. In winter, in the United States the air will require humidification. The outdoor air at, say, zero, contains almost no water; when this air is heated to 70°F. it becomes almost caustic to the tender tracheal mucosa of a child. Moistening of the air should be done without raising the

temperature over 70°F. because this defeats the object, by simultaneously raising the water absorbing power of the air. Mechanical humidifiers are best for this reason. A dusty atmosphere is to be avoided.

In the local care the keynote is "good plumbing." That is to say, throughout each twenty-four hours someone must be present who understands the necessity for and the means of maintaining clear "pipes," natural and artificial. And this person must understand that tracheotomy is not an ultimate object. The objective is to pipe air down to the lungs, and tracheotomy is only a means to that end. Secretions must not be allowed to accumulate and coagulate in the trachea; if they are not coughed out they must be aspirated. If crusts form they must be removed by bronchoscopy; sometimes coagula are so firm as to require forceps removal.

A bedside tray should contain the following:

Sterile gloves.
Sterile gauze.
Scissors.
Probe.
Hemostats (2).
Trousseau dilator.
Duplicate (exact) tracheotomic cannula.
Infant-sized catheter for aspiration.

A doubled 2-foot length of copper wire for pulling gauze through cannulae for cleansing before boiling. Wire gauge number 24 is heavy enough. Tonsil snare wire should not be used because it will damage the thin edge of the inner end of the cannula.

A mechanical aspirator and a tank containing oxygen (plus CO_2, 5 per cent) should be in the room, ready for immediate use.[14]

A bronchoscope, bronchoscopic forceps, cords, battery and aspirating tube should be quickly available.[7]

Dressings are to be changed as frequently as soiled (usually every few hours). This has the effect of keeping the wound washed with sterile exuded serum, which is removed at each change of dressings. The inner cannula is removed, cleansed in lukewarm sterile water and promptly replaced. The outer cannula should be changed within six hours after operation to get rid of clots and inspissated serum; afterward at least once daily. There should be duplicate cannulae and they should be exact duplicates, so the inner cannula of either may be used in the changing of inner cannulae, and the duplicate outer cannula can be ready at all times for immediate substitution. Not only is delay avoided, but also the hasty cleaning that is so likely to be imperfectly done, with resultant damage to the inner end of the cannula. A damaged inner end causes endotracheal mucosal trauma and crusting, and it may lead to perichondritis of the tracheal rings.

Fig. 5. Tracheotomic triangle for creating a mental conception of a safe and rapid technique for emergency tracheotomy. It has nothing to do with the cervical triangles detailed in textbooks on anatomy. The middle line is the safety line, the higher the wider. Below, the safety line narrows to the vanishing point, VP. The upper limit of the safety line is the thyroid notch until the trachea is bared, when the limit falls below the first tracheal ring. In practice the two dark danger lines are pushed back with the left thumb and middle finger as shown in Figure 3, thus throwing the safety line into prominence.[4,8] (From "The Larynx and Its Diseases" by Jackson and Jackson, published by Saunders.)

The patient, if over 2 years of age, may be alarmed at inability to speak. He should be assured that this is only because the air leaks out through the cannula, and that in about ten days he can talk as well as ever by putting his finger on the cannula. This may be demonstrated to him by the surgeon at a dressing.

Fig. 6. Sketch showing finger guarding the knife during incision of the anterior wall of the trachea, to prevent puncture of the posterior tracheo-esophageal party wall. (Cf. Fig. 7.) The length of the blade from the point (P) to the finger stop (F) is so gauged that the point will not reach the tracheo-esophageal party wall, which is very close in children. The hand is ungloved for better delineation. (From "The Larynx and Its Diseases" by Jackson and Jackson, published by Saunders.)

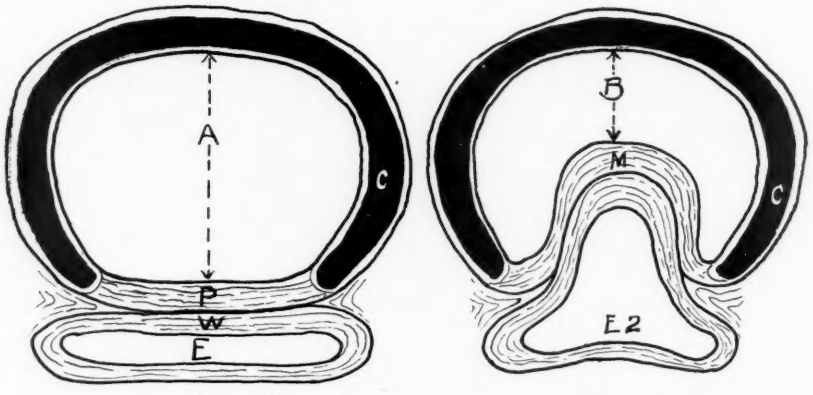

Fig. 7. Schema illustrating the mounding of the posterior tracheal wall during cough in children—a pitfall in tracheotomy. A, cross section of trachea during inspiration. *c*, horseshoe-shaped cartilage called a "ring." Between the heels of the horseshoe the posterior tracheal wall, *p*, is membranous and is integral with the anterior wall, *w*, of the esophagus, *e*, forming a "party wall," *pw*. During expiration the trachea diminishes in all diameters. During the forced expiration of cough the party wall, especially in children, mounds forward, diminishing by about half the anteroposterior diameter, *a* and *b*. When incising the trachea at tracheotomy, if care is not taken to stop the knife (Cf. Fig. 6), there is danger of the point of the knife penetrating through the thin party wall into the esophagus. This disaster is usually fatal from leakage of food and secretions into the trachea whence they are inspirated into the lungs.[19]

The patient, if there are no complications or general contraindications may sit up on the third or fourth day and go about at the

end of a week. The wound may not be quite healed by that time, but there is then no danger of serious infection.

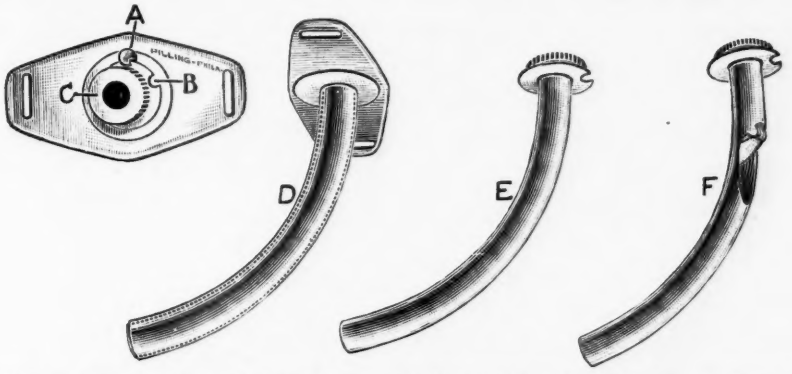

Fig. 8. Improved tracheotomic cannula devised by Chevalier L. Jackson. The shield in these cannulae is free from all obstruction. The advantage of this is that, in wiping the cannula with gauze to remove the secretions before the patient reinspirates them, there is no obstruction and no entanglement to catch the gauze. This is invaluable in the quick, proper and painless wiping of the cannula, especially in children. It is also useful in that there is no obstruction to the finger when it is desired to put the finger over the orifice of the cannula for speaking. Another advantage is that the very greatly lessened bulk in the front of the neck renders it very easy to hide the cannula under the clothing without any pressure of clothing on the cannula. These cannulae are made with the standard curve or any curve that may be required and of any length to fit the patient and the lesion, if tracheal. They are also made with a valve to facilitate talking and to facilitate fixation of the chest in using the arms. This valvular type of cannula is never to be used immediately after operation; in fact, not until a fistula has been formed by the healing of the wound around the standard cannula. The long cane-shaped cannula is made in rigid and vertebrated forms. The soft rubber pilot is a safeguard against making false passages, and, being hollow, it avoids terrifying the patient by shutting off his breathing during the introduction of the cannula.

tion through the mouth into the larynx by the same motions used in O'Dwyer's method of intubation for laryngeal diphtheria, though the instrument itself is quite different.

EMERGENCY TRACHEOTOMY

The best technique of dealing with an asphyxiating patient is to insert a bronchoscope, establish regular respiration through it, and then proceed with a low tracheotomy in an orderly manner. In addition to elimination of hasty tracheotomy, this technique has the advantage of direct laryngoscopic and bronchoscopic inspection of the living pathology present in the particular case. Additionally, the bronchoscope in situ in the trachea makes the operation quite simple, by affording a staff that may be cut down upon. The conversion of an emergency into an orderly procedure can also be accomplished by use of Mosher's "life savers." These are curved tubes with a long straight shank for insertion through the mouth into the larynx by the same motions used in O'Dwyer's method of intubation for laryngeal diphtheria, though the instrument itself is quite different.

If, however, neither the bronchoscope nor the life saver is available an emergency tracheotomy must be done.

The quickest method that is certain in its results is the Chevalier Jackson two-incisions operation.[11] It is done as follows:

Anesthesia. Any patient needing an emergency tracheotomy does not need local anesthesia, and a general anesthetic would be promptly fatal.

Instruments. A knife and a pair of trained hands are enough, but a full surgical equipment as listed above is better.

Position of the Patient. The neck should be thrown into prominence by pushing a roll of fabric of any kind under the shoulders, close to the neck. If the patient is on the floor or pavement, or in a vehicle, the

head may be lifted and the neck brought above the left knee of the kneeling, or preferably, sitting operator.

Technique. For rapid performance it is well for the operator to ignore the details of anatomy and of orderly procedure above described; and to get instead a mental conception of the tracheotomic triangle. (Fig. 5.) He should get the conception of a windpipe in the midline covered by soft tissues through which he must cut, and can cut safely, so long as (*a*) the patient's head is not rotated, (*b*) the cutting is in the midline, (*c*) the operator's left index finger is educated to recognize the feel of the trachea, (*d*) the trachea is thrown into prominence between the operator's left thumb and middle finger. The throwing of the trachea into prominence should be rehearsed at every opportunity, such as on a member of the surgeon's family, a student, orderly or any patient whose neck is being examined. It is the most important feature of the procedure.

Enumeration of Steps. For clearness of description the procedure may be divided into seven steps; but in practice the steps merge into each other so rapidly and smoothly that it seems but a single procedure. (1) Feeling the trachea, fixing it, and throwing it into prominence. (2) Incision through the skin and superficial tissues. (3) Finding the trachea in the tissues and blood with the left index finger. (4) Incision of the trachea. (5) Holding open the slit in the trachea, or insertion of a cannula. (6) Reestablishment of respiration. (7) Hemostasis.

Step 1. Throwing the trachea into prominence and fixing it in the midline are accomplished by pushing back the great vessels well under the sternomastoid muscles. This is done in a second or two with the thumb and index finger of the left hand. (Fig. 3.)

Step 2. With one sweep of the scalpel an incision is made from Adam's apple almost to the suprasternal notch. This incision must go clear through the skin to facilitate free finger dissection. There may be considerable flow of blood but nothing immediately dangerous.

Step 3. Finger dissection to find the trachea. (Fig. 4.) While the left thumb and middle finger are still holding back the great vessels under the sternomastoids the previously idle left index finger quickly locates the trachea by following downward from Adam's apple. The trachea is infallibly identified by the ridgy character of its walls; there is nothing like it in that region. Every medical student has learned, or should have learned the feel of it in the dissecting room. In identifying the trachea the finger at the same time bares its midline of tissue below the cricoid, by pushing aside any overlying tissue; if the isthmus of the thyroid gland intervenes it is pushed downward or pulled up. If it is torn or cut it will not matter. If an anomalous artery is felt crossing the trachea at this point it is pushed down or pulled up.

Step 4. Tracheal incision. The trachea having been identified and bared of tissue, the tip of the index is slid slightly to the operator's left side so that the scalpel in the right hand can be safely guided down along the palmar surface of the index onto the tracheal wall. Two or three rings are incised. In making the incision the middle finger of the right hand makes a guard against deep entrance of the knife that might otherwise go through the posterior tracheal wall into the esophagus.[19] (Fig. 6.)

Step 5. Holding apart the lips of the tracheal incision. There is usually a hiss if the patient is breathing, but the lips of the tracheal incision in most cases lie so closely in contact that insufficient air is permitted to pass. The lips should be spread apart with a Trousseau dilator; if none is available a hemostat will do. Lacking these, the handle of the scalpel may be inserted in the slit and rotated slightly to cause gaping. Of course some blood will trickle into the trachea but cough will quickly expel it and spray it about. The cannula is inserted with its pilot; the pilot is removed if not blown out by the tussive blast. If by reason of deplorable lack of equipment no cannula

is available someone must hold the lip of the tracheal incision apart until a cannula can be obtained or a makeshift devised for temporary use.

Step 6. Artificial respiration must be done if there has been respiratory arrest. Oxygen mixed with 5 per cent carbon dioxide should be liberated at the tracheal opening or greatly insufflated through a catheter. Vaporized amyl nitrite is a good stimulant if the pearls are at hand, as they should be.

Step 7. Hemostasis. As soon as respiration is established hemostasis may be done in the usual way. If artificial respiration is necessary temporary hemostasis may be afforded by packing gauze firmly into the wound and around the cannula.

Difficulties and Pitfalls of Tracheotomy. If the technique given has been closely followed there will be no serious difficulty. Departure from the technique involves risk of pitfalls. A common one is the attempt to give a general anesthetic. Dyspneic patients are dependent largely on the aid of the accessory muscles of respiration under voluntary stimulus. This is abolished as soon as loss of consciousness begins; respiration ceases and unless bronchoscopy or tracheotomy is done within two minutes the respiration cannot be started and the patient asphyxiates. In the aggregate the mortality from this pitfall has been enormous. General anesthesia should never be used for tracheotomy unless a bronchoscope is in situ; and there is no need for it even then. It may be added that *opiates* for the restlessness of air hunger in children needing tracheotomy have often precipitated an emergency tracheotomy, and in many cases have resulted in death by asphyxia.[4,9,11,13]

A short incision is a common pitfall. A long incision gives ample access and this renders the operation easy.

Complete closure of the wound, close up to the cannula, is a pitfall of not infrequent occurrence. A false passage by the cannula going astray may occur at any of the early dressings, and lead to a slow asphyxia. With an open wound the tracheal incision can be found with the Trousseau dilator and the cannula can be seen to enter the trachea.

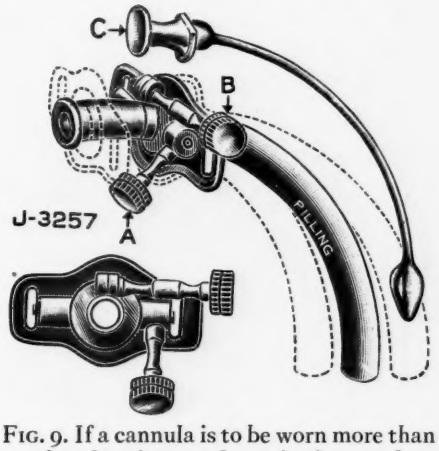

Fig. 9. If a cannula is to be worn more than a few days it must fit perfectly, as otherwise it will cause erosion, ulceration, crusting, hemorrhage and perichondritis. The measuring cannula (C. L. J.) here shown is used to determine the radius of curvature and length of tube and the shield angle.[18]

Mediastinal emphysema is usually due to stitching the wound close up around the cannula. The air in the cervical tissues works downward between the layers into the mediastinum. This pitfall can be avoided by packing the wound open as indicated above. Rarely the air may leak into the pleural cavity causing a *pneumothorax.* Spontaneous pneumothorax has occurred from rupture of the visceral pleura in violent respiratory efforts in impending asphyxia.[11] This may be favored by old adhesions. Unilateral pneumothorax in such cases is rarely followed by empyema and the lung reëxpands normally. Bilateral pneumothorax is quickly fatal unless bronchoscopic oxygen insufflation is promptly instituted and constantly maintained until at least one lung has expanded. Pneumothorax may occur from direct trauma to the pleura in an excessively low tracheotomy.[15]

Hemorrhage in Emergency Tracheotomy. We are indebted to Batson for the knowledge of the anatomic fact that there may be, anomalously, a large artery in the

midline of the neck, but the chance of encountering it in a patient needing an emergency tracheotomy is exceedingly remote. The dissecting finger would quickly detect such a vessel and the finger could not tear it open with any force a surgeon would apply. The finger feels the bared tracheal rings before incising them. If such an anomalous artery should be cut, of course, the surgeon would seize the squirting artery with a hemostat. Obviously the surgeon must be aware of even rare anatomic anomalies, but because of a possibility so remote no patient should be allowed to asphyxiate for want of a prompt emergency tracheotomy.

Pneumonia after tracheotomy is one of the curiosities of medicine. The high frequency of this complication in the literature is due to mistakes of diagnosis. The often fatal pulmonary condition is really an *obstructive atelectasis* completely relievable by bronchoscopic methods. Hundreds of times we have had it reported to us that our tracheotomic patient was "dying of pneumonia." Prompt bronchoscopy almost invariably revealed plugs of thick secretion, or crusts, or both, obstructing bronchial orifices. Bronchoscopic removal caused disappearance of the fever, high respiratory rate and impaired percussion note on which the erroneous diagnosis of pneumonia had been based. Auscultation is not so misleading in these cases.

Pneumonia is an exceedingly rare complication of tracheotomy. If it really does occur bronchoscopic aspiration should be added to medical care and management.

Laryngeal and tracheal stenoses are usually due either to a high tracheotomy or a misfit cannula, two pitfalls that are easily avoided. Tracheotomy should be done below the first ring of the trachea. If this is done there will be no stenosis caused by the tracheotomy.[2,17]

All patients requiring prolonged wearing of a tracheotomic cannula should have the cannula checked for perfect fit.[17] A misfit cannula will cause erosion of the tracheal mucosa, perichondritis and chondral necrosis. If the Roentgen ray shows the cannula has too short or too long a radius of curvature a perfectly fitting cannula must be made from measurements best obtained with the measuring apparatus shown in Figure 9.[18]

Stenosis also occurs from destructive processes of the primary disease, for example diphtheria, syphilis, tuberculosis, typhoid fever.[12] When the cartilaginous framework is destroyed, even partially, the unresisted cicatricial contraction will obliterate the laryngotracheal lumen. This must be frustrated and the lumen restored by the early use of core moulds.[17]

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Surgery was born of a queer muddle of demonology, tribal ritual and social necessity, but in the earliest civilizations it developed rapidly into a lusty infant art.

NON-OPAQUE FOREIGN BODIES IN THE ESOPHAGUS

WITH REPORT OF FOUR CASES

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IN spite of the numerous articles which have appeared in the literature regarding the swallowing of foreign bodies, not infrequently these emergency patients are examined by certain methods which are unsatisfactory, unscientific and occasionally fraught with extreme danger to the patient. It has been our experience that, before a patient with an impacted foreign body in the esophagus consults a laryngologist, he has usually been subjected to several incomplete examinations.

All these patients give the history that while eating meat or fish they felt something stick in their throat which caused them to gag and retch. They immediately resorted to drinking fluids, eating soft bread or potatoes, and were slapped on the back, in an attempt to dislodge the foreign body. Occasionally following these efforts all symptoms disappeared. Often a lump, pain, scratch, or a "feeling of something there" persists in the throat or esophagus, and the patient consults a doctor. The foregoing symptoms may be mild or severe, constant or present only on swallowing. Pain is often referred to the back or to one or both shoulders. The attending physician must decide whether the foreign body has passed into the stomach, causing only an abrasion, or is still lodged in the lumen of the esophagus and in danger of perforating its wall. He must also consider the possibility of dealing with an unduly alarmed individual.

Routine investigation of these patients consists of a search of the pharynx and larynx, sometimes with and frequently without the use of a mirror. Occasionally patients will insist on an *x*-ray examination, for the public has been educated to the infallibility of the Roentgen ray. If these examinations prove negative for foreign body in the esophagus, then the patient is advised to "forget about it," or to swallow dry bread, potatoes, etc. Sometimes blind bouginage is resorted to. These patients then, if they still complain of pain on swallowing, are tacitly labelled "neurotic." This latter diagnosis may be correct, but not infrequently a foreign body is present, and it seems unjustifiable to allow the few to suffer, because of the mental worries of the remainder.

Although endoscopists have advocated and preached the gospel of the wider use of the bronschoscope and the esophagoscope, both in diagnosis and treatment, yet there is considerable reluctance on the part of our medical colleagues in recommending such an examination. For some reason or other, the idea of a fearful and terrible ordeal has been associated with these examinations, and laryngologists may be responsible for some of this. The technical difficulties of these procedures have been overstressed.

It is our feeling that the bronschoscope and esophagoscope should be used much more frequently, in conjunction with all the other accepted methods of examination. This includes a careful and reliable history; a thorough search of the mouth, tonsils, pharynx, nasopharynx, base of tongue, larynx, and pyriform sinuses by direct vision in a good light; and the use of a laryngeal mirror. Fluoroscopic studies of the esophagus should be included, with thin and thick barium mixtures and barium filled capsules. No one method of diagnosing a non-opaque foreign body in the esophagus is 100 per cent accurate, and all of them should be used more freely. We

doubt the advisability of leaving esophagoscopy until the last, or until all other methods fail to reveal the foreign body. The use of the esophagoscope is not only an excellent method of diagnosing foreign bodies, but carries with it a means of treatment which is usually curative.

These points are all well illustrated in the following cases. In the first and second cases the history was suggestive, the *x*-ray negative, the patient insistent and esophagoscopy diagnostic and curative. In the third case the patient was insistent, the fluroscope suggestive, but the esophagoscope was negative. A repeat fluoroscopy with heavy barium was again suggestive. *X*-ray films were positive for retained barium, probably on the foreign body. An immediate esophagoscopy was the direct means of a diagnosis and successful treatment. In the fourth case all examinations, including esophagoscopy, were negative, and the pathologist had to make the diagnosis.

CASE REPORTS

Case I. Miss B., age 25, a single school teacher, had swallowed what she thought was a chicken bone, which seemed to lodge about half way down the esophagus. Almost immediately she had pain in the right axilla, which was aggravated by swallowing. Fluoroscopic studies with heavy barium revealed no evidence of obstruction, and the patient was allowed to go home. She returned the following morning without any improvement of her symptoms, the most outstanding of which was the pain in the right axilla on swallowing. An esophagoscopy was performed and a bone was found lying at the upper constriction, bifurcating the esophagus and probably allowing the barium and capsules to pass unimpeded. The axillary pain disappeared shortly after, and the patient made an uneventful recovery.

Case II. Mrs. L., age 51, a scrub woman, while eating supper developed a sudden pain in the neck radiating to the back. The pain persisted but there was no particular difficulty in swallowing. The patient consulted a hospital where examination and *x*-rays of the throat were pronounced negative. She remained in hospital three days, and the pain in the neck was explained on an arthritic basis.

On the fourth day the patient was seen in

Fig. 1. Non-opaque foreign bodies removed by esophagoscopy.

this hospital because of persistence of the pain. Examination under the fluoroscope with light and heavy barium mixtures and barium capsules revealed no esophageal obstruction. An esophagoscopy revealed a bone in the upper part of the esophagus. This bone extended from behind forward, divided the esophagus into equal parts, and evidently allowed the barium to pass without detection on fluoroscopy.

Case III. Mrs. H., age 34, while eating roast beef for supper, swallowed a bone. She noted something stick in her throat while swallowing, and her throat bled slightly. Severe pain under the sternum and in the left shoulder persisted. The referring physician noted on examination with barium that a lag of the column of barium occurred on fluoroscopy at the upper end of the esophagus. About midnight, the patient was carefully examined with an esophagoscope, but the foreign body could not be located. The pain was very persistent, was relieved by morphia, and was still present the next morning. Fluoroscopy again disclosed a lag of the barium column at the upper end of the esophagus, and *x*-ray film showed a small fleck of barium retained. A second esophagoscopy was done, which revealed, after careful search, a small bit of barium on the posterior wall of the esophagus. The barium could not be wiped off, and on grasping with

forceps the free end of the beef bone was discovered and the bone removed.

Apparently the beef bone was lying in the coats of the esophageal wall, or projecting into the mediastinum. This lady was relieved immediately of her major pain, and recovery was uneventful, though she was watched with some misgiving for several days.

Case iv. S. C., age 20, a young business man, while eating chicken for supper, felt something sharp stick in his throat. At first it seemed to lodge in the upper part of the esophagus, but at the time of his first examination it was felt nearer the stomach. On swallowing, pain was felt in the region of the xiphoid process.

Examination of the throat and fluoroscopy with barium mixture were negative for a retained foreign body. Esophagoscopy showed some injection of the mucous membrane in the mid-thoracic region, but no foreign body could be seen. This patient was kept on sterile fluids and closely observed for a week with symptoms gradually abating. Ten days later the patient stated that all symptoms had disappeared and he was feeling fine. A week later he suddenly bled to death in his bathroom. A coroner's autopsy disclosed a traumatic perforation of the aorta following a perforation of the esophageal wall by the chicken bone.

COMMENT

All patients giving a history of swallowing a non-opaque foreign body should have a careful examination, including esophagoscopy. The accompanying photograph of osseous tissue non-opaque on Roentgen ray examination (Fig. 1) makes us realize that these patients do have a cause for their severe symptoms, and yet our ordinary examination without esophagoscopy may fail to reveal this foreign body. The four case reports presented indicate the seriousness of swallowing foreign bodies, and warrant the conclusion that complaints arising in patients giving this history, demand immediate and exhaustive investigation.

FRACTURES AND DISLOCATIONS OF THE JAWS AND WOUNDS OF THE FACE

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THE management of injuries to the face and jaws has engaged the attention of the general surgeon and the specialist throughout the history of surgery. In the past few decades, however, the incidence of facial injuries has gradually increased and their care has placed an additional demand upon the profession.

In the treatment of facial injuries, the surgeon's concern should be to minimize facial disfigurement and restore function. That the importance of these factors is not fully appreciated is frequently seen in results obtained. The careless approximation of skin edges, the use of large needles and suture material and the failure properly to debride wounds are inexcusable mistakes. Sensitiveness to facial disfigurement varies with different individuals and what may be an ineradicable complex throughout life to one may be a source of pride to another but can well be an economic handicap to both. Therefore, it is demanded of the surgeon that these injuries be repaired to the best of his ability and as far as circumstances, often difficult, will allow.

ETIOLOGY

Fractures of the jaws are either traumatic or pathologic, the latter being relatively rare. At the present time, automobiles are responsible for the greatest number of cases, with fist fights, industrial accidents, falls, etc., following in the order given. In addition to being fewer in number the latter cases are usually less severe.

DIAGNOSIS

In the simple, clear-cut case there is usually no difficulty in establishing the diagnosis, but in the more severely injured cases a detailed clinical examination following a systematized plan is necessary to determine the extent of the injury. As a guide in so doing, the following points should be observed:

1. External injuries of the face, including lacerations, contusions, swellings and ecchymotic areas. Fractures of the mandible may occur at the point of application of the trauma or at some distant point to which the force is transmitted through the bone.

2. Asymmetry in the contour of the face. Flattening of the facial features on one side just below the outer rim of the orbit suggests a depressed fracture of the malar bone. Digital palpation of the orbital rim and zygomatic arch will disclose irregularity at the site of fracture of these structures. Since these fractures are all due to direct trauma, anesthesia of the infraorbital nerve on the affected side is a common sequelae. Depressed fractures of the zygomatic arch may interfere with the forward excursion of the mandible in attempted opening of the mouth.

3. Palpation of the temporomandibular joints. With the index fingers in the external auditory meatus, pressing anteriorly, the action of the condyle is felt in the opening and closing movement of the mandible. Fracture of one or both condyles precludes movement of the articular head. Associated deformities from condylar fractures are shortening of the vertical length of the ramus on the affected side and depression of that area of the face over the joint when the condylar head is displaced.

4. Examination of the oral cavity with especial reference to the occlusion of the teeth. Any alteration of relationship between the upper and lower teeth is indicative of fracture with displacement. Unusual

mobility of several contiguous teeth suggests fracture of the alveolar process. Compound fractures are easily recognized by a break in the mucoperiosteum. Palpable tenderness is usually present at the fracture site and crepitus is a valuable diagnostic sign.

5. Other objective and subjective symptoms. These include areas of anesthesia resulting from nerve injury such as occurs to the lip in mandibular fractures, loss of function and infection.

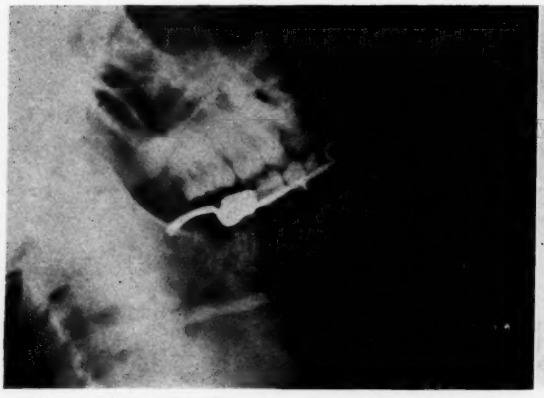

FIG. 1. Dental splint fitted to the arch with an extension to engage the posterior fragment and prevent its being displaced upward by the elevator group of muscles. After adjusting the splint the jaw should be immobilized.

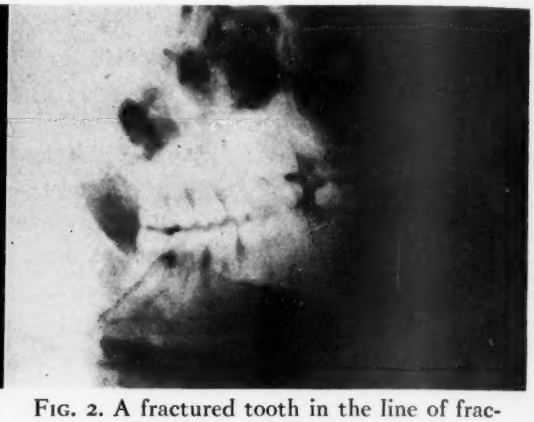

FIG. 2. A fractured tooth in the line of fracture. This tooth was allowed to remain in position to prevent elevation of the posterior fragment. The injured tooth was removed as soon as the posterior fragment was retained by fibrous union.

ROENTGENOGRAPHIC EXAMINATION

Fractures of the jaws are occasionally overlooked because of inadequate Roentgen examination. This is one of the most valuable diagnostic aids, but should not be used to the exclusion of other diagnostic measures.

The horizontal portion of the mandible, excluding the symphysis, is best shown in the lateral position. The symphysis is best demonstrated with a large intraoral film, $2\frac{1}{2} \times 3\frac{1}{4}$ inches, placed between the occlusal surfaces of the teeth and the rays directed from below the chin. An anteroposterior projection is necessary to demonstrate the rami of the mandible and the condylar relationships.

Fractures of the maxillae are more difficult to demonstrate radiographically than are those of the mandible. Roentgenograms made in the Waters position of the bones of the upper face will give the best visualization of these structures. The zygomatic arch and malar bones are best outlined with the skull in the vertical position.

In addition to showing the presence of a fracture the Roentgen examination will disclose such additional information as the direction of the fracture line, fragmentation of the bone, presence of foreign body in the fracture line or adjacent tissues, injuries to the teeth and position of fragments after reduction.

Poorly angulated and processed *x*-rays may be very misleading and only those without distortion and clear-cut as to detail should be accepted as a basis for diagnostic deductions.

TREATMENT

Generally speaking, the earlier reduction is done the better, but the nature and extent of the injury often precludes other than emergency treatment. If the wound is contaminated with dirt or other foreign substance 1500 units of tetanus antitoxin is administered. Hemorrhage is controlled and lacerations of the skin and mucous membrane closed. The Barton bandage, commonly applied as a temporary means

of treating mandibular fractures, is inefficient when there is displacement. The backward pressure exerted on the chin by the bandage only produces more displacement and pain.

Mandibular Fractures. With but few exceptions the restoration and maintenance of occlusion between the upper and lower teeth is all that is necessary in the reduction of fractures of the mandible.[1]

The first exception is a fracture at or near the angle of the jaw and lacking a tooth in the posterior fragment. The elevator muscles tend to displace the posterior fragment upward. Many methods are available to control this displaced posterior fragment, such as direct fixation of the bone, or a dental splint as described by Schaeffer and Skinner,[2] with an appropriate extension beyond the line of fracture and forked over the bone to hold it in position. (Fig. 1.) Every effort should be made to conserve a tooth in the posterior fragment. Even though it may be damaged or its roots be in the line of fracture it will in all probability serve to control the posterior fragment until no further fixation is necessary. (Fig. 2.)

The second exception consists of fractures of edentulous mandibles. With slight displacement, insufficient to cause nonunion or deformity, no treatment is indicated other than rest. Amends for the resulting irregularity of the alveolar ridge can be made with artificial dentures. If the displacement is marked, reduction is effected by direct bone fixation or by circumferential wiring. For direct bone fixation an incision is made along the lower border of the mandible immediately below the fracture. The fracture line is exposed and debrided. Holes are drilled through the bone about 1 cm. from the fracture line and if the size of the mandible will permit, two holes are placed on either side of the fracture. A 22 gauge silver wire is laced in a criss-cross fashion between the holes, the reduction made and the wires tightened. Care should be exercised in the tightening process to see that the wires are not tight enough to cause pressure resorption, but yet are tight enough to hold the fragments in approximation. If the fracture is compound the wound is closed with provision for drainage, otherwise not. The wire may or may not be left in permanently, depending upon the progress of the healing. If no infection occurs and if the presence of the wire does not interfere with denture construction, there is no positive indication for its removal.

With circumferential wiring, 25 gauge soft silver wire or any other suitable ligature wires are passed around the mandible, one on either side of the fracture line and tightened over a saddle-like splint which has previously been fitted to the ridge. The lower denture serves as a satisfactory splint. This method has the disadvantages of not giving the exact reduction and approximation of the fragments that is afforded by the open view method and causing the discomfort of wearing the splint. Traumatic ulceration of the soft tissue will develop as a result of impinging the mucoperiosteum between the bone and the splint.

By the large, intermaxillary fixation is the method of choice for treating fractures of the mandible. Reduction and fixation has been greatly smplified by the use of intermaxillary rubber band traction. This method of treating the jaw fractures is a distinct advance over the generally employed method of using wire alone for interdental ligation. In many clinics, including our own, it has largely supplanted all other methods, especially if a sufficient number of teeth are present in both jaws. It entails nothing more than the attachment of small aluminum shells, described by Woodward,[3] to the teeth of the upper and lower jaws with 25 gauge stainless steel wire and attaching the rubber bands between the opposing sheels of the upper and lower teeth. The mechanism thus employed for reduction serves equally well for immobilization. The fragments are held in apposition with slight movement, which materially aids repair. This factor, com-

bined with ease and simplicity of application, elimination of manipulation of fragments, and provision for good dental hygiene is testimony to the value of the method.

Fig. 3. Arch bar wired to the teeth. Continuity of the bar is broken at the site of fracture and the rubber band traction adjusted between the upper and lower bars. The rubber bands serve equally well for immobilization and for reduction. (Dingman.)

If the teeth are insufficient in number or stability a half round 16 gauge German silver arch bar wired to the buccal surfaces of the teeth, will provide sufficient attachment for rubber bands to effect reduction. (Fig. 3.)

The great majority of mandibular fractures are compounded to the mouth in consequence of which they are liable to infection. Some advocate the establishment of drainage in all such cases at the time of reduction by making a stab wound immediately below the fracture line. Since less than one-half of such cases become infected it would seem more conservative to treat the infection, if and when it occurs, by localizing and draining the abscess with an extraoral incision at the most dependent point of the swelling. Efforts should always be made to keep these incisions beneath the shadow line of the mandible to avoid unsightly scarring.

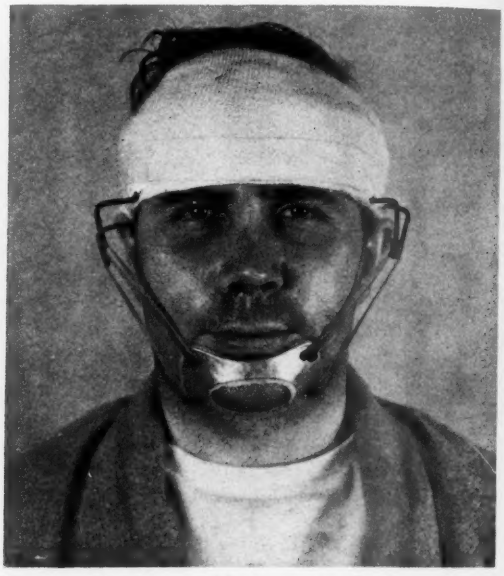

Fig. 4. Aluminum chin cap attached to plaster of Paris head cast with long rubber bands to reduce and maintain in position a transverse fracture of the maxilla. Normal occlusion is effected and maintained throughout the healing process.

Fractures of the condyle and rami are as amenable to the rubber band method of reduction as are fractures of the body of the mandible. Fractures through the neck of the condyle with displacement require three to four weeks of immobilization. Even though the condylar head is displaced from the glenoid fossa, open reduction is contraindicated. Ankylosis is not a sequela of condylar fractures unless the joint surfaces are involved. Open reduction is hazardous and unwarranted.

Fractures of the Maxilla. Upper jaw fractures vary in extent from simple fractures of the alveolus to complete separation of the bones of the face from the skull. The fracture may be unilateral or bilateral and it may involve the maxilla at any level. In complete transverse fracture the bones of the face move as a unit on manipulation and require fixation outside of the mouth for immobilization.

Unilateral fractures of the maxilla are reduced by intermaxillary fixation using

only the unaffected side if the displacement is downward. The constant pressure exerted by the rubber bands will gradually force the displaced fragments back to normal position. If displacement is upward and backward and of the impacted type the traction is applied to both sides and the displaced fragment is brought down until the teeth contained therein occlude with the teeth of the lower jaw.

Complete transverse fractures if displaced downward are reduced by encircling the mandible with slight elastic tension attached to a skull cap. This cap may be of plaster of Paris or it may be a regular surgeon's cap. If the former is used a chin cap, swedged from aluminum and lined with felt with four posts attached, one at each corner, can easily be utilized to exert an upward pressure by attaching long rubber bands between the paster of Paris head cap and the chin cap. (Fig. 4.) Care must be exercised in the amount of upward pressure applied, as many of the fractures are comminuted and complicated by cranial injury.

If either or both of the jaws are edentulous, the most efficient method of supporting the bones is by the use of a splint adapted to the upper jaw to which side arms are fastened and curved to extend from the corners of the mouth and posteriorly along the face. (Fig. 5.) Adhesive strapping is attached to the extended arms and fastened over the vertex of the skull. An upper denture makes a satisfactory splint to which the arms may be vulcanized.

Depressed Fractures of the Malar Bone and Zygomatic Arch. These fractures are always due to direct force and the malar bone, usually fractures at or near its juncture with other bones. The deformity is characterized by depression of the facial contour below the outer border of the eye. Correction should be effected as soon as possible after the injury, as union in malposition occurs rapidly. Of the many methods advocated for raising the depressed bone the intra-antral gives uniformly good results. It has the added advantage of clearing the antrum of all blood clots and providing adequate drainage. The antrum is opened through its outer anterior wall and the bones elevated to their normal position. It is rarely necessary to pack the antrum to maintain the bones in position unless the structures are badly shattered. The Gillies[4] method is also very useful, especially so if the zygomatic arch is also depressed. Through a short, transverse incision made above the hairline, in front of the ear, a long, flat periosteal elevator is forced below the malar bone, keeping it just outside the temporal muscle. By padding the head above the shank of the elevator and using it as a fulcrum, the necessary elevating pressure can be produced. The short incision is closed and leaves no visible scar as it is above the hairline.

Fig. 5. Cast metal splint covering the upper jaw and palate to which side arms are attached and extended from the corner of the mouth backward over the face. Adhesive strapping is employed to attach the splint to a plaster of Paris skull cap. This method is not advisable if both upper and lower teeth are present as the splint interferes with obtaining normal occlusion of the teeth.

MANDIBULAR DISLOCATION

When the jaws are closed or at repose the head of the condyle is in the glenoid

fossa. Interposed between the head of the condyle and the roof of the fossa, and dividing the joint into two separate synovial cavities, is an interarticular disc or pad. As the jaw opens, the condyle, together with the interarticular disc, glides forward until it rests under the emenentia articularis. If the jaw is forced beyond this point it may become locked, thus constituting the usual anterior dislocation. In addition to the anterior dislocation, Blair and Ivy[5] have described superior, posterior and lateral dislocations. They are of such infrequent occurrence that mention is only made in passing. Dislocations may occur as the result of injury or by forcibly opening the mouth beyond its normal limits. Dental extractions and throat operations under general anesthesia in which the mouth is too widely opened with a gag are frequent causes.

Symptoms. In unilateral dislocations the chin is deviated to the unaffected side while in bilateral dislocations the chin will be well centered but in a protruded position. The patient is unable to open and close the mouth and the teeth are in malocclusion. Palpation and *x*-ray examination disclose the condyle well in advance of the articular eminence and a depression is felt in the area of the joint. Dislocation differs from fracture in that in the latter some of the teeth may be in occlusion or can be brought into occlusion by manipulation.

Treatment. In cases of not too long standing reduction is accomplished by downward traction at the angles of the jaw with pressure exerted posteriorly. At the same time the chin should be slightly raised, thus reversing the movement that the condyle undergoes while leaving the socket. This manipulation is performed by placing the thumbs, protected by gauze, over the occlusal surfaces of the bicuspids and molars and the fingers under the chin. In protracted cases, open reduction may be necessary.

After reduction the opening movement is limited for several days by bandaging the jaws with a Barton bandage or if teeth are present by interdental ligation.

WOUNDS OF THE FACE

Fractures and dislocations of the jaws are frequently accompanied by wounds and lacerations of the face. With the highly competitive struggle for present day existence and the psychological effect of ugly scars and deformities it is demanded of the surgeon that he acquaint himself with the details of repair of these facial wounds to obtain a pleasing result or refer the patient to one adequately trained in this field of endeavor.

The toilet of the wound is the initial consideration. All facial wounds are potentially infected and should be thoroughly cleansed with tincture of green soap and water followed by a thorough irrigation of normal saline solution. This also holds true for excoriated surfaces in which dirt and foreign material may be ground and which if allowed to heal will give the skin a tattooed appearance. The wound should be inspected for bits of foreign material all of which should be removed. As in fractures that are suspected of being contaminated, a prophylactic dose of 1500 units of antitetanus serum and 1250 units of gas bacillus serum is administered after testing the patient for horse serum sensitivity.

After the toilet of the wound is completed and bleeding controlled it is ready for closure. If the wound edge is ragged and irregular it is straightened by excising the ragged edge. Likewise, contused wound edges, liable to undergo necrosis, are excised to bring healthy tissue into approximation. The wound edges are undermined in order to approximate them without tension. To facilitate suturing and minimal scar formation the skin edges should be vertical.

Suture material should be of fine gauge and non-capillary in action. The needle should be of the nontraumatic type. The subcutaneous tissue is closed first with interrupted sutures cut short. The skin is then closed by interrupted sutures, closely

placed with considerable attention paid to approximation of the skin edges or by a running subcuticular stitch as described by Lange.[6] In using the latter, the suture material should be brought to the surface each ¾ inch, to allow for cutting during removal.

If there has been considerable undermining of the tissue a pressure bandage should be applied. Gauze, held firmly in place with roll bandage, is adequate. Where no pressure is required a gauze collodion dressing over the wound is adequate, more comfortably tolerated by the patient, and provides some support to the wound edges. Areas denuded of the superficial epithelium are covered with gauze impregnated with an antiseptic ointment.

The early removal of sutures is imperative for minimal scar formation. Interrupted skin sutures should be removed on the third or fourth day. Removing alternate sutures on the third day and the remainder on the fourth is a safe procedure.

The extent and location of lacerations together with the presence or absence of infection are the deciding factors in scar production. In spite of thorough initial care and closure one is occasionally faced with a displeasing scar when healing is completed. Such cases are all amenable to secondary repair when conditions are more favorable for a satisfactory result.

CONCLUSIONS

1. Injuries of the face and jaws should be accorded the benefit of thorough clinical as well as radiographic examination.

2. Reduction and immobilization of fractured jaws have been greatly simplified by the use of intermaxillary rubber band traction.

3. For minimal facial disfigurement, the repair of soft tissue wounds of the face demands thorough and meticulous initial care.

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CONTUSIONS, CRUSHING INJURIES AND WOUNDS OF THE THORAX*

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INTRODUCTION

THE results of trauma to the chest are best understood after appreciation of certain of the functions of the organs involved and of the derangements produced by injuries. The bony thorax constitutes a protective elastic cage which is subject to some variation in size with respiratory movements. This cage is closed inferiorly by the domes of the diaphragm, and at the superior thoracic aperture transmits the trachea and esophagus, as well as the great vessels and nerves, and contains also the extreme apices of the lungs. The fascial planes of the interior of the thorax blend with those of the deep fascia of the neck so that air released into the mediastinum quickly appears at the base of the neck.

Among its other functions connected with respiration the chest wall in its form and movements is partly responsible for the negative pressure in the potential pleural space and its structural integrity is of vital importance in maintaining this pressure.

The diaphragm is protected from the effect of blows by the bony thorax, but its regulatory mechanism is quite sensitive and in association with severe traumata, particularly to the lower ribs, may be paralyzed, with the result that the diaphragm assumes a much higher position than normal, and may even be penetrated in the process of aspiration of the pleural cavity at a usually safe level.

The bony framework of the thoracic cage is very elastic in childhood, but becomes more brittle with age. Hence, particularly in elderly people, fractures may be caused by relatively slight injury.

Any wound of the thorax which enters the pleural cavity, unless it is immediately closed either by falling together of its edges, if it be a small stab or puncture wound, or by suture or by means of air-tight dressings if it is large, results in what is known as open pneumothorax. In this condition there is a free communication between the pleural cavity and the outside which causes the intrapleural negative pressure to be replaced by atmospheric pressure. The lung on the involved side is thus partly collapsed and loses for the most part its respiratory function. In addition, unless fixed, the mediastinum is dislocated toward the opposite side with consequent compression of that lung and further decrease in the available respiratory capacity. Other factors such as loss of the aspiratory function of the normally negative intrathoracic pressure on the great veins and the waste effort in respiratory movements in sucking air into the pleural cavity where it cannot be utilized in oxygenating the blood also enter in. It is not to be wondered at, therefore, that open thoracic wounds are of very serious moment and should be closed at once.

MINOR CONTUSIONS AND NON-PENETRATING WOUNDS OF THE SOFT PARTS

There is little concerning the contusions and non-penetrating wounds of the soft parts, when present alone, which distinguishes them from similar lesions elsewhere in the body. Hematomata of considerable size may develop, but rarely require active treatment. The only point requiring comment is that wounds of the soft parts of the chest wall may be asso-

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ciated with some subcutaneous emphysema of the surrounding tissues due to the respiratory movements even when the thoracic wall is not penetrated or the lung ruptured. While one should always suspect a penetrating wound or rupture of the lung when this sign is present, the absence of pneumothorax and the limited extent of the emphysema usually are of diagnostic significance. All lacerations, if seen within six to eight hours of injury, should be closed after debridement and a firm dressing applied.

MAJOR CONTUSIONS AND CRUSHING INJURIES OF THE THORAX

The thorax may be subjected to contusions or crushing injuries as a result of blows, falls, flying debris or in automobile, airplane or railroad accidents. Many of these are similar to the injuries described in the World War, and the major crushing injuries resulting from caving in of trenches or dugouts find their counterparts in the accidents in industrial excavations and in crowds subjected to panic as in fires and other disasters. The less serious injuries give rise to few symptoms other than those of contusions elsewhere and are recovered from promptly. However, even in the minor cases thorough examination is imperative, as occasionally fractured ribs or unsuspected pneumothorax or hemothorax may be discovered. Many are of a severe nature and are quite as apt to lead to serious consequences as the penetrating wounds of the chest.

A classification of these injuries on the basis of clinical and pathologic findings applicable to individual cases is difficult to set up, but they may be divided roughly into three groups: (1) a group in which, following severe injury, there are symptoms of serious intrathoracic damage but in which physical and laboratory examination fails to reveal evidence of actual anatomic change—to this type of case the term "commotio thoracis" has been applied; (2) a group in which the condition known as traumatic asphyxia is present—in this state, which follows severe compression or crushing injury, the patient presents a remarkable dark bluish discoloration of the face, neck and upper chest; and finally (3) a group, comprising by far the larger number of patients with serious thoracic injury, in which both symptoms and signs of severe intrathoracic damage are evident.

Commotio Thoracis. This term refers to a definite clinical entity the exact explanation of which is somewhat obscure and which should only be diagnosed after careful examination has failed to reveal other reasons for the symptoms. It was seen in the war in association with tangential blows from grenades or other flying objects or in men near an exploding shell but who were not actually struck by any of its fragments. In clinical life it may occur in explosions or in other accidents in which the individual is badly shaken up and but narrowly escapes serious injury. It would seem that there may be an added element of tremendous emotional strain at the same time. The symptoms are those of syncope, the patient falling unconscious with cold, pale skin and barely perceptible pulse. The pulse rate is slow and often irregular, the respirations slow and shallow. From this state the patient may recover completely, but in some cases treatment is unavailing and death results. Autopsies were performed on a number of such cases in the last war in which no internal or external injury was found to explain the fatal outcome. This condition has been compared to shock or to cerebral concussion and many authors have stressed the importance of nervous impulses in producing the slow pulse and respirations and the sudden drop in blood pressure.

The diagnosis should only be made after the most careful examinations have failed to reveal definite evidence of either intrathoracic or intracranial injury.

The treatment is supportive, as in shock, combined with the administration of oxygen with 5 to 7 per cent CO_2. The administration of oxygen with enough CO_2 added to prevent washing out this sub-

stance from the blood stream constitutes one of the most useful measures in the treatment of intrathoracic injuries.

Traumatic Asphyxia. This peculiar condition is characterized as the name suggests by a dark blue discoloration of the face, neck, upper chest, and less often of the shoulders and upper arms. It is sometimes seen in patients who have suffered a sudden and relatively brief compression of either or both the thorax and upper abdomen. Most often this force is applied directly, the individual being caught between cars or crushed under some heavy object, but the condition may occur when a person is "doubled up" by a force exerted against the upper part of the back and forcing the abdomen and chest against the knees (jack-knife injury). There is usually no direct injury of the head and neck.

The discoloration is commonly most marked about the lids, lips and nose, and less so about the ears and neck. The bluish background of the discoloration is often studded with minute petechial hemorrhages, and these also appear on the mucosae of the mouth and throat and in the auditory meatus. Commonly, the discoloration is absent at points where something such as a collar-band, suspenders, or even creases of clothing have pressed upon the underlying skin.

By about the fourth day the color begins to fade and gradually disappears, but in doing so leaves behind none of the color changes associated with extravasation of blood except in sites where petechial hemorrhages have been present. This fact indicates that the discoloration is not due to actual extravasation of blood but is associated with marked stasis in the vessels of the skin. This view is supported by the examination of sections of skin removed from discolored areas which failed to reveal any evidence of blood.

In addition to the discoloration, there is commonly present considerable edema of the face, and particularly of the eyes and lips. Subconjunctival hemorrhages are frequently seen and there may be bleeding from the nose or mouth. Visual disturbances have been reported in about 10 per cent of the cases, some of which have been transient, but in some blindness, associated with progressive optic atrophy, has resulted. This may be explained on the basis of hemorrhage into the retina or degenerative changes secondary to vascular stasis and edema. Unconsciousness of short duration has been noted in about 25 per cent of the cases reported in the literature.

While the appearance of the patient is alarming, in the absence of the complications noted or of severe associated injuries, the condition is not in itself of serious consequence and most of the cases recover completely. However, these patients should be most carefully examined and observed and such supportive measures employed as may be indicated.

In a typical case, a young girl, A. B., age 19, was admitted to the wards of the New York Hospital on March 18, 1939 after an automobile accident. She had been pinned beneath the car in which she was riding, which had overturned following collision with another car. After being extricated, she was brought immediately to the hospital.

On admission, she lay on the examining table in extreme distress. Her temperature was 38.6°C. (rectal), her pulse 122, respirations 22. Blood pressure was not taken on admission. She was struggling violently for breath. Her respirations were heaving and a quantity of frothy, bloody material was sprayed from the nose and mouth. She could not be aroused although from time to time she showed apparently voluntary motions of all the extremities.

There was a very dark purple cyanosis involving the third and fourth interspaces. Over the anterior chest and shoulders the cyanosis had a mottled or irregularly streaked distribution. The face was a dark purple color, the eyes were wide and staring, the jaws clenched, the tongue between the teeth. Scalp and skull showed no bony deformities or lacerations, the pupils reacted equally to light and accommodation, but the fundi could not be visualized at the time. Both nostrils contained blood, but there were no obvious bleeding points or deformities. No bleeding from the ears was

observed, but blood was present in the mouth and pharynx.

The neck was thick and distended anteriorly, its skin cyanotic. The larynx and trachea were not palpable. The chest was symmetrical, with no bony deformities. There was no subcutaneous emphysema. A few coarse râles were heard throughout both lungs, but otherwise they were clear to percussion and auscultation. The heart was not enlarged, maintained regular rhythm, with sounds distant but no murmurs. Pulse was of good quality.

There was a large abrasion over the posteromedial aspect of the right calf, but no deformity or limitation of motion.

Urine examination and the Kline test proved negative. Red blood cells numbered 4,400,000, white cells 24,000. The differential was normal and the hemoglobin 94 per cent. *X*-rays of spine, chest and right leg showed no evidence of fracture. A diagnosis of fractured larynx with traumatic asphyxia was made. A tracheotomy immediately on admission brought prompt improvement in respirations. Examination of the pelvis showed fractures of the ischium and pubis on the left, with the fragments in good position.

The temperature rose to 39°c., but gradually declined until the fifth day after her admission. There was slight pneumonitis, by *x*-ray, but no definite pneumonia at this time.

The patient's color gradually improved, the tracheotomy tube was removed on the tenth day after admission. About the sixteenth day after operation her complexion was perfectly normal. From the fourteenth day onward she made a perfectly uneventful recovery. Indirect laryngoscopy on the tenth day following admission showed a minimal amount of swelling in the larynx, but no vocal cord paralysis. The patient's tracheotomy wound healed up promptly and cleanly. She was kept flat in bed for six weeks after admission because of the fractured pelvis. On the thirty-eighth day after admission *x*-rays of the fractured pelvis showed the fragments to be in good position, with considerable callus formation.

The patient was allowed out of bed on the thirty-ninth day after admission and was discharged on the forty-first day. On discharge her general condition was excellent. Examination of the optic fundi showed no evidence of scars or hemorrhage. Her skin had entirely cleared up.

While in this case there was the complication of fracture of the larynx which required tracheotomy, the initial picture and the course of the traumatic asphyxia were typical.

Serious Thoracic Injuries. The third group comprising the greater number includes those cases of serious thoracic injuries. These may be associated not only with extensive injury to the chest wall resulting in massive hematomata in the muscles and subcutaneous tissues and multiple fractures of the ribs, but also may cause serious damage to the intrathoracic viscera including lungs, pleura, pericardium, heart, great vessels, trachea and diaphragm. In contusions of the lower thorax, the spleen, liver, kidneys and gastrointestinal tract may also be injured.

Fractures of the ribs may cause laceration of the pleura which of itself is of little consequence, but when combined with more extensive injuries to the thoracic wall and lung may give rise to widespread subcutaneous emphysema, hemothorax or pneumothorax.

Several types of pulmonary injury may be seen. Thus the lung may be lacerated by a sharp fragment of rib or may be ruptured due to compressing trauma when the glottis is closed. A common pathologic finding in cases of contusion is hemorrhagic consolidation of the lung. Here, due perhaps to rupture of the interalveolar capillaries, the alveoli become filled with blood which is gradually absorbed as the condition clears. While the pulmonary damage is commonly most severe on the side toward the contusion, "contrecoup" injury of the opposite lung may be encountered and may even be more extensive than in the lung nearest the point of impact.

Wounds of the Thorax. Wounds of the chest in civil life, while differing somewhat in type and in the frequency of the more minor variety, present many of the same problems as those seen in military surgery. Thus, shotgun wounds of the chest are in many ways similar to the extensive shell wounds seen during the last war, and the

modern high velocity steel jacketed revolver bullets produce wounds quite similar to rifle bullets. Only in those series containing a preponderance of stab wounds from "switch blade" knives or from icepicks do the chest wounds of civil life appear somewhat less serious. Thus in a series reported from the Cincinnati General Hospital in which bullet wounds predominated, the mortality was 39 per cent, a figure quite comparable to those reported from base hospitals in the war. Elkin,[1] on the other hand, reports a series from Atlanta 86 per cent of which were knife or icepick stab wounds, with a 6 per cent mortality.

The immediate mortality obviously depends on the type of wound and the damage to intrathoracic viscera; even in those who survive the initial injury, these factors are of importance. First of all, such wounds may be classified into open and closed varieties. In the former there is a sufficiently large opening into the pleural cavity to permit the ingress of air and the development of open pneumothorax. Such wounds are of extreme gravity and should be closed at once. In others the wound is small or of such character that its edges fall together and the amount of air entering the pleura is minimal. In the absence of complications these wounds are of little consequence.

Symptoms. All patients with serious thoracic injuries are in shock when first seen and this may mask the specific symptoms of intrathoracic damage. As recovery from shock occurs, however, pain, difficult respiration, oppression in the chest, and cough, often with bloody sputum, appear and the cyanosis associated with the shock continues. Rapidly spreading subcutaneous emphysema may be encountered. The respirations are of a peculiar grunting or gasping type and the patient is in great distress. In any extensive injury to the ribs the abdominal muscles, particularly of the involved side, are splinted.

Treatment of Chest Injuries. In most instances patients with major chest injuries are in shock when first seen and it is this condition which requires immediate treatment. Heat and morphia, in the absence of associated head injury, to alleviate pain and distress are most useful, and intravenous infusion or transfusion may be required. The patient's position must be adapted to his comfort since individuals with serious chest injuries often do not tolerate well a prone or head down position. The administration of oxygen through an intranasal catheter or by means of an oxygen tent when available is important in relieving respiratory distress. Open chest wounds are to be closed either temporarily by means of dressings, or, better, by suture at the earliest possible moment.

With the exception of these measures, the treatment of chest injuries is largely concerned with the effects of damage to intrathoracic organs. Certain of these may require immediate attention, while in others treatment may be delayed.

The three conditions requiring most urgent emergency treatment are tension pneumothorax, rapidly accumulating hemothorax and multiple section fractures of the ribs with loss of rigidity of a portion of the chest wall, the so-called "stove-in-chest."

Tension pneumothorax is a form of closed pneumothorax resulting from a laceration or rupture of the lung of such a character that it exerts a valve-like action on the ingress and egress of air from the lung into the pleural cavity. Under such circumstances the increasingly forceful respirations of the patient serve only to draw more air into the pleura with consequent increase in the intrapleural pressure which may reach an extraordinarily high level. The effects of such pressure with marked dislocation of the mediastinum and compression of the great veins are extremely serious.

On inspection such patients are cyanotic and are making rapid and desperate respiratory efforts which produce a bulging of the tissues at the base of the neck on each expiration. The chest is bulging on the involved side and moves but little with

respiration. The veins of the neck and shoulders are prominent. Percussion yields a high pitched drum-like tympanitic note on the side of the pneumothorax and demonstrates the marked dislocation of the mediastinal structures. The pulse rate is rapid and unless the patient is in shock, is forceful in the early stages, decreasing in volume as the pressure on the great veins interferes with the return of blood to the right heart.

The treatment is immediate aspiration of the pleural cavity at a high point, with the removal of sufficient air to bring the intrapleural pressure to zero. In some cases the pressure in the pleural cavity is so elevated as to blow the plunger forcibly out of an aspirating syringe. The intrapleural pressure having been sufficiently reduced, some idea of the amount of air escaping from the lung can be obtained by connecting the needle to a pneumothorax apparatus in reverse and measuring the rate of accumulation of air. If the air continues to accumulate in the pleural cavity at a rapid rate, it is necessary to insert a small tube through an intercostal stab wound, placing its lower end barely under the surface of water in a bottle beneath the bed, thereby preventing the pressure in the pleura from rising above atmospheric pressure. The tube should be left in until air no longer escapes, which is usually the case in three or four days.

These cases require very prompt diagnosis and treatment, but few, if any, results in surgery are more spectacular than the relief afforded such patients by the reduction of intrapleural pressure. Pneumothorax of lesser grade is best treated expectantly since if the air is entering the pleura from a wound in the lung, collapse of this organ may be an important aid to healing and the air will be gradually absorbed.

Hemothorax may occur with contusions, crushing injuries, or wounds of the chest from injury to a vessel in the chest wall such as an intercostal or internal mammary artery, or to a pulmonary vessel or to both. Because the pressure in the vessels of the lung is only 40 mm. of Hg. at most, the accumulation of blood following injury to the lung is much less rapid than is the case when an intercostal artery is the source of the hemorrhage. Moreover, when the lung is torn the bleeding tends to cease as the lung is compressed by the rising level of the blood in the pleural cavity, as well as by the coincident pneumothorax. Bleeding from the internal mammary or from an intercostal vessel, however, may be quite severe and continue longer since the pressure in these vessels is relatively so high. Accumulation of blood in the pleural cavity should be suspected in all thoracic injuries and will be found to be present, to some extent at least, in almost all of those of severe grade, often with associated pneumothorax.

Physical examination yields evidence of fluid, with or without air in the pleural cavity, usually with more or less dislocation of the mediastinum. The latter depends to some extent on the amount of blood present. *X*-ray is confirmatory and shows a fluid level when air is also present. Aspiration of the chest yields fresh blood which does not clot even on standing.

Treatment of hemothorax should be conservative at first, except in cases of massive accumulations in which there are urgent pressure symptoms, since too early aspiration of any quantity of blood may only result in recurrence of the hemorrhage as the intrapleural pressure is reduced. When, because of urgent symptoms, immediate or early evacuation of some of the blood is imperative, it should be replaced with about an equivalent quantity of air, thereby maintaining some of the pressure but substituting a compressible medium.

After forty-eight hours partial evacuation may be begun, removing about 500 c.c. daily. The blood becomes progressively diluted with a transudate caused by the presence of blood in the pleura. Small quantities will be absorbed but large amounts disappear quite slowly and leave behind deforming adhesions or extensive fibrosis as the

accumulation of fibrin in the costophrenic angle is organized. If there is infection in the hemothorax, it is treated as an empyema, simple drainage usually sufficing, but in gunshot wounds retained foreign bodies such as fragments of clothing may make wider thoracotomy with exploration of the pleural cavity necessary.

Multiple section fracture of the ribs or "stove-in-chest" is a very serious type of injury, particularly in older patients in whom it is most commonly seen. Due to the fact that the supporting rigidity of the ribs is lost, the chest wall moves in during inspiration and out during expiration, and corresponding movement takes place in the mediastinum. Usually the lung of the same side and occasionally the controlateral lung are contused with resulting complications, and since elderly people are most often the victims, the incidence of pneumonia is very high.

The diagnosis of the condition presents little difficulty since the paradoxical movements of the involved area are quite evident. The patients are in great distress both from pain and dyspnea.

The treatment consists in applying a firm dressing over the involved area and strapping the chest on that side. The patient should be placed in an oxygen tent and the injured side supported by pillows or the patient induced to lie on that side if possible.

Subcutaneous emphysema, while a striking finding, is not of serious import unless it be associated with mediastinal emphysema. When the latter is present it is commonly combined with pneumothorax, often under considerable tension, and will disappear when and if the intrapleural pressure is relieved. Other measures include incision in the base of the neck, but this adds the risk of gravitating mediastinitis and is to be avoided if possible. On the whole, subcutaneous emphysema tends to disappear once the source of the air and its access to the subcutaneous tissue is eliminated.

Injuries to the Heart and Pericardium. Injuries to the heart and pericardium, as well as to the great vessels, are not so common in connection with contusions and crushing injuries as is the case with penetrating wounds, although, as has been pointed out by Beck, cardiac contusions are probably of much more common occurrence than was formerly believed. Occasionally the pericardium may be torn or ruptured with resulting hemo- or pneumohemopericardium. In the so-called "steering wheel" injury described by Beck[2] in which this structure is forcefully jammed against the lower sternum in collision of automobiles, there may be serious compression of the heart resulting in actual rupture, in fragmentation of the myocardium or in its major contusion. Such patients may subsequently suffer severe attacks or even die from what appears to be coronary occlusion with myocardial infarction, commonly in the second week after the accident.

All cases in which cardiac contusion seems likely should be carefully observed for symptoms and signs suggesting coronary disease, and kept in bed for a period of at least two weeks.

Gunshot Wounds. Gunshot wounds of the heart are almost uniformly and quickly fatal, survival being possible only in the extremely rare case in which very slight damage to the cardiac muscle is produced. Somewhat less serious are the simple stab wounds of the heart which receive immediate attention. Such patients may be free from symptoms for a minute or so, only to collapse as the pericardium becomes filled with blood. The diagnosis rests on such a history plus evidence of acute cardiac tamponade. As blood accumulates in the pericardium, diastole is interfered with, the venous pressure rises with engorgement of the superficial veins of the neck and circulatory failure results with feeble or absent pulse and arterial blood pressure too low to measure.

The only possible treatment is operation with relief of the tamponade and suture of

the cardiac wound. This has now been accomplished in a fairly large number of cases. However, only a minute fraction of the patients with cardiac wounds survive long enough to be treated, and even after suture of the wound a high percentage succumb to complications such as pericarditis or pneumonia.

Combined Thoracic and Abdominal Wounds. Concomitant injury of abdominal viscera is a serious complication of many thoracic wounds and should always be suspected and ruled out. The seriousness of such wounds depends on the causative agent and the structures involved, but all are dangerous and require urgent treatment. The diagnosis is often difficult and occasionally is only possible after exploration, but in all, the symptoms and signs of intra-abdominal injury are added to those of the chest wound.

Wounds on the right side involving the liver alone give rise to serious hemorrhage, and the leakage of bile into the pleura or peritoneum is a complicating factor. Injury to the liver is so difficult to handle surgically and the danger of diaphragmatic hernia on the right so comparatively small, that such wounds are best treated conservatively at first, reserving operation for the drainage of secondary abscess in the pleura or peritoneum if this supervenes. However, it is often necessary to operate to rule out injury to other organs.

On the left, the picture is quite different and the diagnosis somewhat easier. *X*-ray may show herniation of the stomach or intestine through the diaphragm, or may demonstrate the presence of gas free in the peritoneal cavity. The latter may cause the liver dulness to be absent on percussion, a very valuable sign of this condition. Stab wounds of the spleen bleed freely, and if this organ is traversed by a bullet the hydraulic force resulting causes it to be shattered to such a degree that at operation it is only a mass of pulp. The kidney may also be shattered by a bullet, and stab wounds of the organ may cause considerable bleeding. Blood evenly suspended in the urine is highly suggestive of kidney injury, and the seepage of urine into the peritoneum or retroperitoneal tissues produces a necrotizing inflammation such as is seen in the subcutaneous tissues following rupture of the urethra.

Combined thoracic and abdominal wounds require operation as soon as the patient's condition will permit, and in most instances the abdominal approach is to be preferred except where intrathoracic exploration is also advisable. Almost all stab wounds can be attacked satisfactorily by laparotomy, and wounds of the diaphragm sutured from below, and, in addition, a more adequate abdominal exploration carried out.

All perforations of the stomach or intestine must be sought out and closed. In wounds of the spleen this organ must be attacked and removed immediately on opening the abdomen, since it may be bleeding vigorously. Renal wounds are dangerous because of hemorrhage and the possibility of extravasation of urine into the tissues. Nephrectomy is indicated if the organ be seriously damaged, but sometimes the insertion of drains through a stab wound in the flank is sufficient. With this exception, all operative wounds should be closed completely, preferably with through-and-through sutures of silver wire to prevent subsequent evisceration.

SUMMARY AND GENERAL COMMENT

Except for the minor contusions of the chest and simple fractures of the ribs, all thoracic injuries may have serious consequences and should be assumed to be associated with intrathoracic damage until this is ruled out. In crushing injuries and wounds of the chest, damage to both thoracic and abdominal viscera is occasionally seen and must be carefully sought for, but in many instances of contusions or crushing injuries abdominal symptoms present soon after injury tend to clear up, as they are often of the referred type. All open wounds entering the pleural cavities are to be closed at once.

Almost all patients with serious chest injuries are in shock when first seen and this is the first condition to be treated. Heat and morphia, in the absence of associated head injury, are most important measures. The patient's position must be accommodated to his comfort and circulation since elevation of the foot of the bed or stretcher may increase respiratory distress. The administration of oxygen mixed with a small percentage of CO_2 is required in most cases and is perhaps the most important single measure in the treatment of thoracic injuries. It affords considerable comfort to the patient and is of great aid in relieving the strain on the cardiorespiratory mechanism. The gas may be administered either by means of a catheter introduced through the nose to the posterior pharynx or, preferably, by means of an oxygen tent. Transfusion of blood or infusion of normal saline and glucose may be indicated. A firm dressing should be applied in all cases of fractured ribs or loss of stability of the chest wall.

Accurate diagnosis of the type and extent of any intrathoracic damage should be made as soon as possible. Aspiration of air or of blood accumulating in the chest may be necessary. In the case of pneumothorax the needle should be inserted at a point high in the chest, while blood should be aspirated through the seventh or eighth interspaces in the posterior axillary line.

Hemoptysis tends to disappear and subcutaneous emphysema is absorbed once its source is cut off. Pulmonary lesions such as collapse or pneumonia require specific measures, but acute hemorrhagic infiltration usually clears spontaneously.

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EMERGENCY SURGERY OF THE HEART*

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GENERAL CONSIDERATIONS

THE heart, like other thoracic viscera, works under a narrow margin of safety. Rapid changes in pressure relationships, particularly in the pericardium, affect the filling and emptying of the heart, and, if unrelieved, will quickly bring about a standstill of the cardiac mechanism.

Normally the intrapericardial pressure is less than that of the atmosphere, and the pressure in the intrathoracic portions of the venae cavae is probably negative. With the rapid accumulation of fluid in the pericardium, as from pus or blood, the venous pressure rises, and after it reaches a height sufficient to overcome the increased intrapericardial resistance, blood enters the heart, and the circulation continues. Thus, an increasing intrapericardial pressure must be overcome by an ever increasing venous pressure if the circulation is to be maintained. Normally the venous pressure ranges between 75 and 120 mm. of water. In rapidly increasing accumulations of fluid the pericardium cannot distend sufficiently nor can the venous pressure rise to such a level as to allow the filling of the heart for any length of time. However, I have noted a venous pressure as high as 400 mm. of water in acute compression of the heart and have seen this pressure maintained for as long as thirty minutes without a fatal result. Where the tamponade of the heart is gradually produced (serous effusion), the pericardium is slowly distended and a high venous pressure will maintain the circulation for days.

Acute tamponade leads to cerebral anemia, for when the heart can no longer fill, it can no longer empty. Release of tamponade is, therefore, a matter of first importance, and demands immediate treatment. The symptoms are a low or unobtainable arterial pressure, a high or rising venous pressure, and a quiet heart. The pulse is weak or absent, and the veins, particularly those of the neck, are prominent and strutted. Because of the venous stasis there is a marked pallid cyanosis of the lips and tongue.

Operations of emergency will, therefore, involve those conditions giving rise to acute compression; wounds and suppuration. In addition, the removal of emboli blocking the pulmonary artery and resuscitation of the stopped heart are considered.

WOUNDS OF THE HEART

Wounds of the heart, though relatively rare, are being reported with increasing frequency but the condition is often overlooked. Early diagnosis is necessary, for delay in operating is rapidly fatal. Every surgeon should realize that at any time the necessity may arise for immediate cardiorrhaphy. He should, therefore, have a definite knowledge of the anatomy and physiology relating to the surgery of this field. In addition he should have in mind a technique of approach and suture applicable to most cases. This technique should be improved by cadaver dissections and operations upon animals.

Diagnosis. Wounds of the heart which are amenable to suture are usually produced by a knife or ice pick. Gunshot wounds are more apt to prove fatal before operation can be carried out, but the same principles of diagnosis and the same technique of suture are applicable.

Because of its position in relation to the anterior chest wall, wounds of the right ventricle are more numerous, but wounds

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of all four chambers as well as those of the intrapericardial portions of the great vessels may be encountered. (Fig. 1.) The

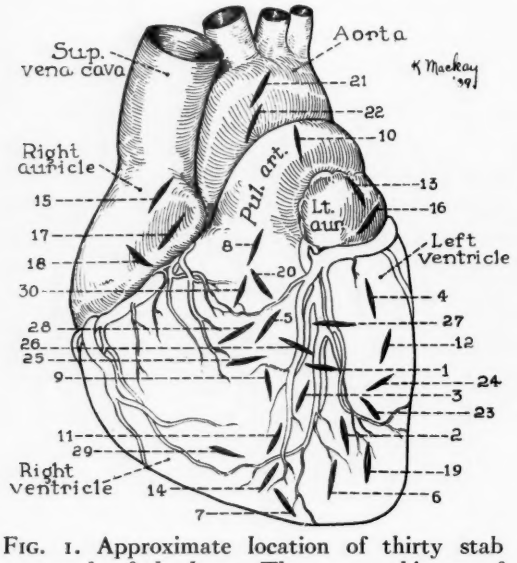

Fig. 1. Approximate location of thirty stab wounds of the heart. There were thirteen of the right ventricle, nine of the left ventricle, five of the auricles, one of the pulmonary artery and two of the aorta.

exact location of the wound can only be surmised before operation, since symptoms from bleeding or tamponade will be the same, regardless of the location. Death may occur from rapid loss of blood either into the chest or to the outside, but death is more likely to occur as a result of tamponade.

The *history* is usually characteristic. There is freedom from symptoms for several minutes after the injury, followed by exhaustion and then loss of consciousness. Either stupor or wild delirium may follow. Patients have been known to walk several blocks or to continue fighting for as long as five minutes after a wound of the heart. Bleeding is profuse at first, but soon stops. This train of symptoms is due to a rapid but gradual tamponade. When the heart is wounded, it bleeds freely to the outside and usually into the pleural cavity as well. At the same time some blood collects in the pericardium and when 100 to 200 c.c. have so collected, the heart is compressed. Contractions become weak, and bleeding to the outside stops. With the rise in intrapericardial pressure, the venae cavae can no longer empty normal quantities of blood to the heart, and cerebral

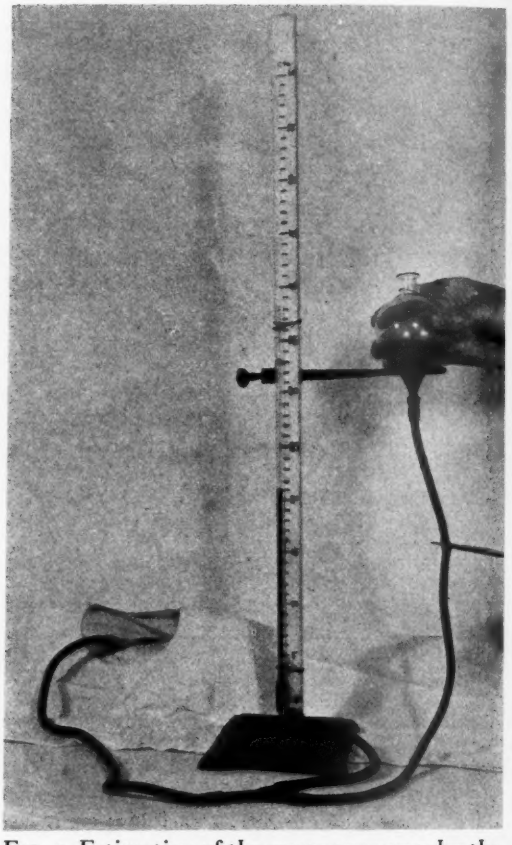

Fig. 2. Estimation of the venous pressure by the direct method. The needle is in the median basilic vein. The fluid has been colored for the purpose of illustration.

anemia, as evidenced by unconsciousness, results.

The position and direction of the wound may aid in diagnosis but the course of a bullet, or even a knife thrust, is notoriously misleading, although those near the left of the sternum from the second to the fifth interspaces are most apt to injure the heart.

The skin is usually cold and moist, and because of the venous congestion there is a pallid cyanosis of the lips and tongue. The heart sounds are weak, often irregular, and the pulse is weak or imperceptible.

The arterial pressure is lowered, even unobtainable, and the venous pressure is raised as evidenced by prominent strutted veins, particularly those of the neck. By

direct measurement this pressure is frequently above 200 mm. of water, and a rise to 400 mm. of water has been observed. Such a pressure is consistent with life if not wound, followed by rapid collapse and unconsciousness.

2. Heart sounds are weak, as is the pulse.

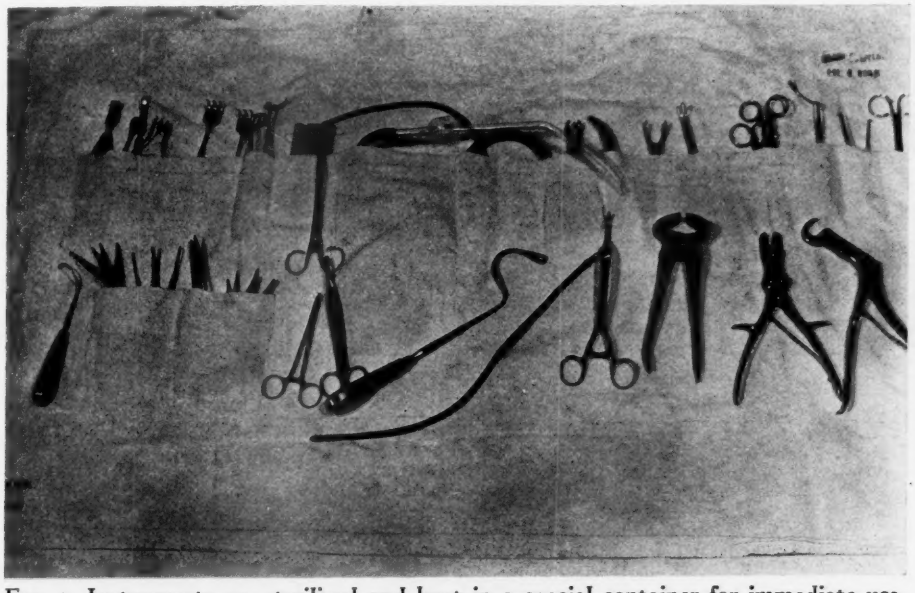

Fig. 3. Instruments are sterilized and kept in a special container for immediate use.

maintained for too long a period. Venous pressure readings should be done by the direct method by inserting a needle into a basilic vein and noting on an attached manometer the height at which a column of physiologic salt solution is maintained. (Fig. 2.) The patient's body should be horizontal, and the vein should be on a level with the heart.

Roentgenograms are of no value, since death may occur from an amount of blood in the pericardial sac too small to cause a noticeable change in the size and contour of the heart shadow. *Fluoroscopic examination is of great value*, since the normal pulsations are prevented by a small accumulation of blood in the pericardial sac. Of all the diagnostic aids, this is the most accurate in proving or disproving one's suspicions of cardiac tamponade. It had best be done with the portable fluoroscope, for with this unit the patient need only be turned on his side for the examination.

To summarize:

1. There is usually a history of freedom from symptoms for several minutes after a

3. The arterial pressure is lowered.

4. The venous pressure is raised.

5. Fluoroscopic examination shows a quiet heart.

Operation should be carried out as soon as the diagnosis is established. To hasten and facilitate this, all necessary instruments should be kept ready in a separate container and sterilized by autoclave. (Fig. 3.) Since infection of the pericardium and pleura is a frequent complication, the operation should be carried out with meticulous care. While preparations are being made, sufficient morphine should be given to insure rest and quiet. The head should be lowered and the body kept warm. Theoretically, intravenous infusions are of little value so long as tamponade is present, but where excessive hemorrhage has occurred, it is indicated. The administration of a 6 per cent solution of acacia may be life saving, and autotransfusion of citrated blood removed during the operation should be given when possible. Blood transfusion should be done as soon as possible after the release of the tamponade.

Anesthesia. Inhalation anesthesia is preferable to local anesthesia for several reasons. The pleura may have been opened by the wound, or may be accidentally opened during the operation, and nitrous oxide and oxygen under positive pressure is necessary for the inflation of the lung. The difficulties of heart suture require that the patient be quiet, but these patients are usually widely excited or are apt to become so with release of the tamponade. Unless completely anesthetized their struggles may interfere with the operation at the most inopportune time.

Suture of the Heart. The incision should be so planned as to give the best exposure with the least trauma. It must also be made with some consideration as to the position of the external wound. Although the pleura is usually injured when the heart is wounded, further tearing of this membrane should be avoided if possible, for it adds greatly to the shock of the patient. For that reason dissection of the pleura from the pericardium is best begun in the fourth or fifth interspace because of its usual reflection to the left at that point. Unless the skin wound is well to the right of the sternum, the approach to the heart should always be made to the left of the sternum, and the incision should be so planned that it can readily be enlarged if the heart wound is not easily located.

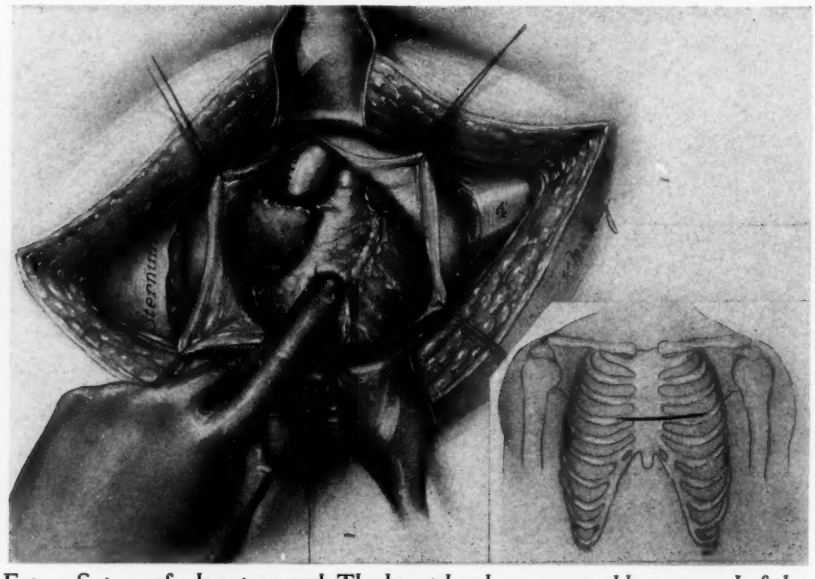

FIG. 4. Suture of a heart wound. The heart has been exposed by removal of the fourth costal cartilage and a portion of the sternum. The suture is passed through the wound beneath the finger which temporarily occludes the opening.

With these factors in mind, experience has shown that a long transverse incision extending well across the sternum gives the best exposure. (Fig. 4.) By this approach one or two ribs can be removed, and, if necessary, the adjacent costal cartilages cut and a portion of the sternum removed. The pectoralis major muscle is separated in the direction of its fibers and can easily be retracted from the surface of three ribs. One or two ribs with their costal cartilages are then removed. Dissection should begin well out on the rib which can be easily lifted from its periosteal bed and cut without injuring the pleura. By lifting the rib the cartilage can then be removed with less danger of injury to the pleura than if the cartilaginous portion is removed first. The internal mammary vessels are ligated and cut, the triangularis muscle is divided and the pleura displaced outward by careful gauze and finger dissection.

A second incision, and one giving excellent exposure, consists of turning a musculocutaneous flap laterally and removing of a suture directly under the finger. This is left untied for the moment and is held in the left hand for traction and hemostasis

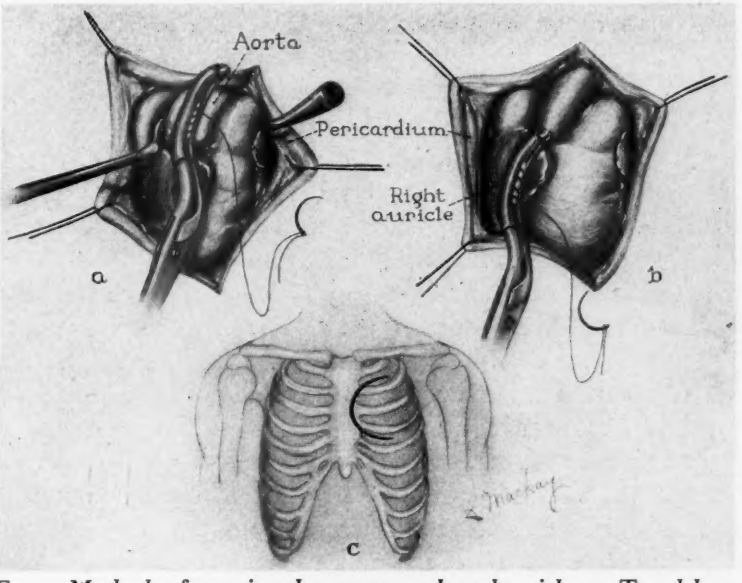

Fig. 5. Methods of suturing the great vessels and auricles. *a*, Trendelenburg probe has been passed through the sinus behind the aorta and pulmonary artery in order to bring the vessels into better view and partially to constrict bleeding. Trendelenburg clamp is shown applied to a wound in the aorta to facilitate suturing. *b*, Trendelenburg clamp applied to a wound of the auricle. *c*, a second incision for approach to the heart.

two or more costal cartilages and ribs. (Fig. 5.) It requires more time to open and close the chest wall and is more likely to induce shock.

The pericardium will be tense, bulging and blue, and its pulsations will be weak and imperceptible. If the wound in the pericardium is seen, it should be enlarged, or, if not readily found, it is opened between stay sutures of silk. Occasionally the heart wound can be located before the blood and clots are removed before the heart starts bleeding profusely. If it is not immediately seen, the blood and clots are removed by suction. When the intrapericardial pressure is relieved, the bleeding becomes marked, as the contractions of the heart increase in force. When the wound is located, and it is most often found in the right ventricle, its closure is facilitated by placing the index finger of the left hand over it. In this way the bleeding will be impeded sufficiently to allow the passage while other sutures are placed and tied. They should pass well into the substance of the muscle, but not into the chamber of the heart. Fine black silk on curved calyx-eye needles is the material of choice. Heart muscle is extremely friable, and for this reason, the *finger should not be placed in the wound*, and sutures should be tied with only enough tension to approximate the edges. (Fig. 4.)

Injuries to the coronary vessels may require ligature, but are not necessarily fatal, unless the patient is old or the vessels are already the seat of sclerosis.

Wounds of an auricle, or the right ventricle behind the sternum, or in the lateral or posterior portion of the left ventricle, are difficult to close because of their position. Here the placing of a stay suture through the apex, as advocated by Ballance and by Beck, is of value in rotating the heart into a position where sutures can be placed.

Hemorrhage from a wound of the intrapericardial portions of the great vessels may be checked by passing the Trendelenburg probe behind them and impeding the flow of blood until sutures can be placed. (Fig. 5.)

In the wound of an auricle, the Trendelenburg clamp may be applied to check the flow of blood until sutures are placed. (Fig. 5.)

During the course of the operation, the heart may fibrillate, or even stop beating, especially when traction is applied. Should this occur, the operation should be momentarily stopped until normal contractions are resumed. If contractions cease or become weak, 1 c.c. of 1:1000 solution of adrenalin should be injected directly into the heart muscle. Gentle massage by pressure between the index finger and the thumb will often restore the heart beat.

After suture and control of the hemorrhage the pericardium is cleansed by suction and flushing with salt solution. The pericardium is loosely closed with interrupted sutures of silk, leaving sufficient space between the sutures for the escape of any fluid which may accumulate. Occasionally the heart dilates to such an extent that complete closure of the pericardium is impossible. The muscle, fascia, and skin are then closed without drainage.

After operation the patient should be placed in an oxygen tent. Fowler's position will usually facilitate breathing. Morphine should be given in sufficient amounts to insure quiet and rest.

Since the pleura and lung are often injured at the time of the heart injury, hemopneumothorax is frequently present. If its extent is such as to cause embarrassment of respiration, aspiration of the chest should be done, but in the absence of symptoms it is better to allow absorption of the air and blood.

Immediate prognosis depends largely upon the interval between injury and operation. Delay may cause death from hemorrhage or tamponade or both. It likewise depends upon the character and extent of the injury; a bullet usually causes two wounds of the wall or septum with greater hemorrhage and loss of tissue. The location of the wound is of prognostic importance; about 80 per cent with wounds of the right ventricle recover. This is probably because the approach to this chamber and its suture is easier. Wounds of the auricles and the great vessels are more hazardous because of the difficulty of approach and suture of these thin-walled structures.

The *postoperative prognosis* is dependent upon infection. Pneumonia and purulent pericarditis are the cause of death in 75 per cent of the operative cases ending fatally. While pericardial adhesions undoubtedly form after these injuries, they are not of such a character as to produce symptoms either by constriction or by increasing the work of the heart.

SUPPURATIVE PERICARDITIS

This condition is frequently overlooked because it is usually a complication of infection elsewhere, and its symptoms are overshadowed by the primary disease. It is to be looked for as a complication of rheumatic heart disease, pneumonia, empyema of the pleura, osteomyelitis, and septicemia. It may follow trauma, as a penetrating wound or contusion. The continuance of a septic course after pneumonia or empyema should make one suspicious of its presence.

The organisms most frequently found are the pneumococcus, streptococcus and staphylococcus. General symptoms are the same as those of infection elsewhere; fever, usually picket-fence, chills, leucocytosis, sweating, anorexia, and rapid wasting. The pulse is rapid, usually paradoxical. There may be pericardial or substernal pain, dysphagia, and difficult breathing. The neck veins are distended and there is a pallid cyanosis. Cardiac tamponade is evidenced by a weak pulse, distant heart sounds, a high venous and a low arterial pressure.

The area of cardiac dulness is increased, and at some time in the course of the

disease a friction rub may be noted. Frequently the liver can be felt. The roentgenogram is of great value in accurately determining the size and contour of the pericardial shadow, and fluoroscopic examination will show a decrease or even absence in the cardiac pulsation.

Certain diagnosis can only be ascertained by puncture but this is an extremely dangerous procedure. Numerous cases of injury to the heart or coronary vessels with subsequent bleeding have been reported and infection may follow the course of the needle into the pleura or lung. If it is done, the safest place is at the left costoxiphoid angle, directing the needle upward and backward. By this approach the pleura is not entered and the needle reaches the lower and posterior part of the distended pericardial sac. Even with the pericardium distended with fluid the heart assumes an anterior position and pus located posteriorly and laterally may be missed if the puncture is carried out anteriorly. On the whole *it is safer to expose the pericardium by operation.*

The pericardium may be approached for drainage by a number of methods. The incision usually employed is the hockey stick one (Fig. 6) along the left lower edge of the sternum and extending out over the fifth and sixth costal cartilages. After the deep structures have been incised and retracted, about 2 inches of the fifth cartilage is removed and the wound further enlarged by removal of a portion of the sternum. The internal mammary vessels are ligated and cut. The triangularis sterni muscle is incised and the edge of the pleura, which can be seen overlapping the pericardium, is carefully pushed back to the left. Should the pleura be accidentally opened, the operation should be delayed and the wound packed for forty-eight hours in order to allow adhesions to close the pleural opening. The pericardium is best opened between stay sutures of fine silk. There may be fine adhesions about the heart which should be separated gently with the finger. A small catheter can be passed to each side of the heart and behind it for irrigation with saline solution.

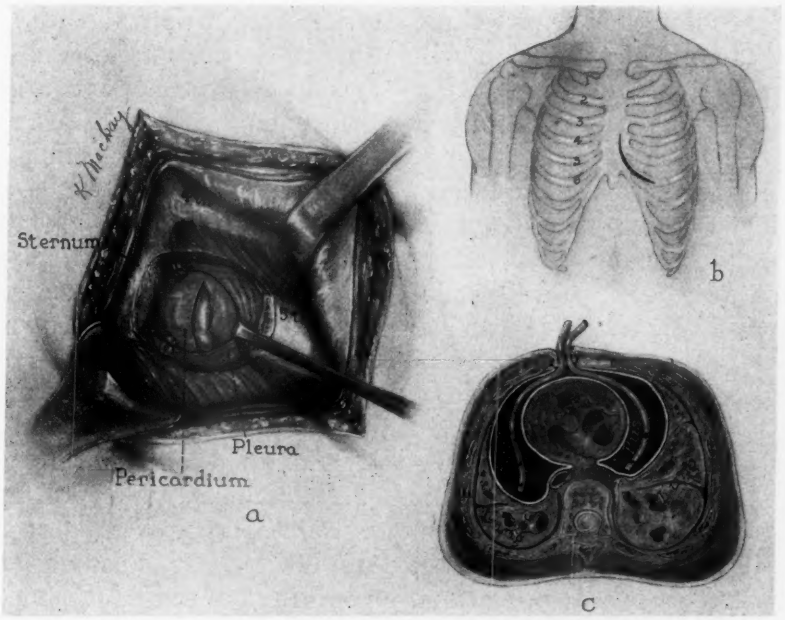

Fig. 6. Drainage of purulent pericarditis. *a*, pericardium exposed by removal of the fifth costal cartliage and a portion of the sternum. *b*, the incision. *c*, cross section showing the position of the drains and the stitching of the pericardium to the subcutaneous tissues.

(Fig. 6.) The edges of the pericardium are sewed to the skin or subcutaneous tissues to prevent too rapid closure, and the catheters, which are left for drainage, need not remain in place more than two or three days. Frequent changing of position will facilitate drainage, particularly if the patient lies on the abdomen several times a day.

Early operation is imperative and should be carried out even before fluid becomes thick. It is, therefore, classed as an emergency operation because the rapid accumulation of pus will produce cardiac tamponade, and death may result from this condition as well as from a generalized infection.

Without operation practically all patients die. With drainage the mortality is about 50 per cent, depending largely upon the nature of the primary infection. If it follows pneumonia or empyema or trauma, the prognosis is good, but if it is but a part of pyemia, the result is usually fatal.

PULMONARY EMBOLUS

There is nothing which produces such a feeling of helplessness on the part of the surgeon as a pulmonary embolus. It frequently comes without warning in a patient believed to be recovering, and the result is usually fatal. In half the cases death takes place within five minutes but others may survive for several hours. It is to be looked for where large veins have been ligated, as in hysterectomy, or where phlebitis follows operation.

Effort should, therefore, be directed towards its prevention. This will depend upon the elimination of the causes of thrombosis; the careful handling of tissues, particularly the ligation of vessels, the stimulation of the circulation, and the prevention of slowing of the blood stream. This latter is best accomplished by early active motion of the patient, and the frequent changing of the patient's position and the raising and lowering of the head and foot of the bed. Where Fowler's position is indicated, the legs should be lowered several times daily to prevent constriction of the venous flow at Poupart's ligaments. The use of tight adhesive and binders, particularly in the upper abdomen, constricts respiration and hinders the return flow to the heart. Binders should be loose and deep breathing encouraged.

Pulmonary emboli account for about 6 per cent of all deaths following operation, and surgical attempts to remove them should always be considered. Since it is "difficult to fix indications for operation" (Nyström), and many apparently hopeless cases spontaneously recover, the question arises whether the dangers of the operation justify its performance.

Trendelenburg described the symptoms of pulmonary embolism as "sudden collapse, pallor, lividity of the lips, loss of pulse, together with deep and distressed respiration." It is usually accompanied by vomiting, a sense of constriction in the chest and the fear of impending death. Since these symptoms and signs are similar to those of coronary occlusion, every effort should be made to differentiate between these conditions. If conditions are suitable for operation and the operating team has been trained for its performance, the patient should be immediately moved into the operating room and prepared for operation.

Trendelenburg's original procedure was carried out through a T-shaped incision through which a portion of the second rib and cartilage was removed. He purposely opened the pleura and exposed the pericardium. The pericardium is opened and a catheter is passed through the great sinus by a special instrument and with this the aorta and pulmonary arteries can be constricted. (Fig. 7.) The artery, which lies anterior to the aorta, is then opened for a distance of 2 cm. and clots removed by forceps and suction. It must be remembered that the left pulmonary artery passes directly to the left, whereas the right is directed posteriorly. After removal of the clots, the opening is held together by a curved clamp and the wound sutured with

continuous silk and reinforced with interrupted sutures of the same material.

If the heart has stopped beating, it should be gently massaged at the apex between the thumb and first two fingers and 1 c.c. of 1:1000 solution of adrenalin should be injected into the heart muscle.

The wound in the pulmonary artery is closed, the pericardium is approximated with interrupted sutures of silk and the wound closed in layers with sutures of the same material. Nyström has modified this method and has pointed out that an opening in the pleura is to be carefully avoided since it adds greatly to the shock of the operation. He opens the chest through a longitudinal incision at the left of the sternum (Fig. 7) and resects a portion of the second, third and fourth ribs with their cartilages. The pleura, which is seen overlapping the pericardium at the fourth rib, is then carefully pushed aside and the pericardium opened high up over the great vessels. As in other operations upon the heart, the patient should be immediately placed in an oxygen tent.

This operation has now been performed over thirty times and about one-third of the patients have survived the operation.

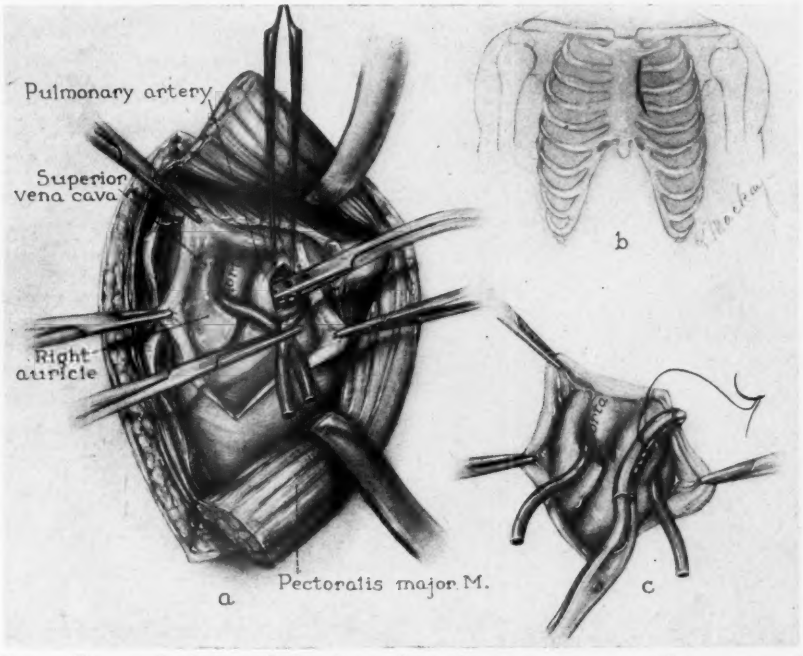

Fig. 7 Removal of an embolus from the pulmonary artery. *a*, the aorta and pulmonary artery are temporarily occluded by a rubber band. The pulmonary artery is held open by a specially devised clamp and the embolus is removed with forceps followed by suction. *b*, the incision. *c*, the wound is occluded with a clamp and closed with a continuous suture of silk.

Trendelenburg pointed out that the constriction of the vessels should not exceed forty-five seconds. Nyström and Blalock have found that this may be increased to two minutes if only the pulmonary artery is constricted. During the course of the operation it may be necessary frequently to release temporarily the constriction of this vessel.

RESUSCITATION OF THE HEART

Sudden heart failure is a specter which constantly confronts the surgeon, for although it rarely occurs, in the majority of instances resuscitation is impossible. The attributable causes are many and varied. Chief among these are mechanical disturbances to the heart itself during operations upon that organ and the pericardium. As already mentioned, traction or pressure may cause fibrillation or arrest, and is a signal for temporary abandonment of the procedure until normal rhythm is

established. Any operation within the chest, such as a lobectomy, the removal of a mediastinal tumor, or even the aspiration

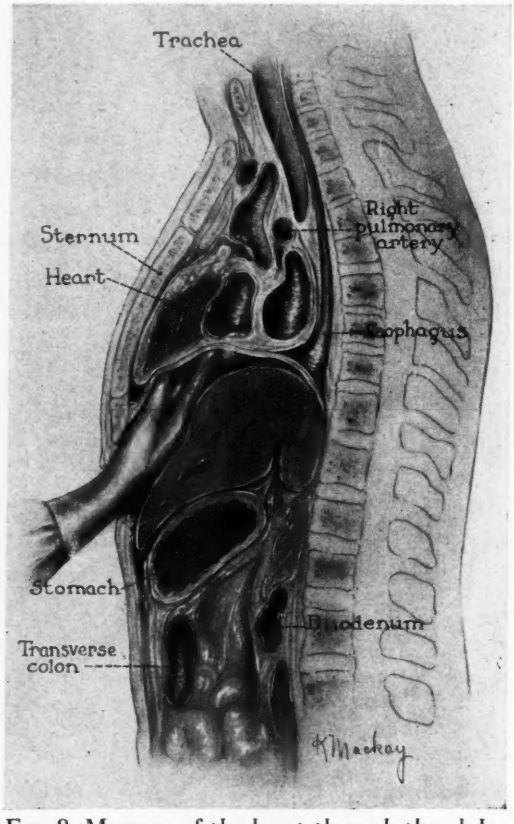

FIG. 8. Massage of the heart through the abdomen. Incision has been made in the epigastrium and the right hand is passed over the liver to the under surface of the diaphragm.

of the pleural cavity, may bring about cardiac standstill.

Of more practical importance is the occurrence of circulatory collapse during the performance of an operation outside the chest. While the exact cause is unknown, it follows deep anesthetic narcosis, hemorrhage, shock, and "status lymphaticus." Often the heart stops without warning at the beginning of an operation—at the time of the skin incision—and this is therefore considered the result of a nervous reflex.

Whatever the cause, attempts have long been made at resuscitation, although progress has been impeded by inability to reproduce the condition experimentally except by narcosis or operations upon the heart. At the time when chloroform was generally used, cases were numerous and resuscitation experiments were begun. Chief and earliest among these were those of the American surgeon Watson (1887) who, in a series of sixty experiments on dogs, showed that resuscitation was possible either by massage or by needle puncture. Since then numerous attempts to revive the stopped heart have been made in man. The number of permanent recoveries is small, probably less than 25 per cent, and there is no accurate statistical evidence to show that any one method is superior to any other.

The physiologic basis for resuscitation attempts is well summarized by Hyman (1930): "The success of the intracardiac injection procedure . . . is apparently due more to the effect of the puncture wound made in the wall of the heart than to the chemical substance injected. The myocardium of the normal asystolic heart rapidly becomes irritable with the onset of anoxemia. Under these conditions, any mechanical stimulation may irritate the heart to automatic contraction, and the success of massage and percussion of the heart for resuscitation can be explained on this basis. The puncture wound made by the injecting needle becomes a focus of increased irritability, from which a stimulus for myocardial contraction may be developed. The first contractions of the heart after injection are always extrasystoles. The initial extrasystolic arhythmia may give way quickly to a normal sinus rhythm with prompt recovery on the part of the patient. However, when the period of anoxemia has been so prolonged or so intense that there is considerable disturbance in the electrodynamic factors controlling myocardial contraction, the initial extrasystolic arhythmia may persist and may be quickly followed by a rapid sequence of ectopic beats. Such a condition leads to pathological fatigue of the ventricles, which may be followed by ventricular fibrillation. Ventricular fibrillation is an extremely hazardous disturbance of the heart and is usually accompanied by immediate collapse of the circulation and death of the patient. This phenomenon explains

the secondary collapse of the circulation often seen following what has apparently been a successful resuscitation of an asystolic heart."

The resuscitation methods generally employed are (1) needle puncture, (2) cardiac injection, (3) cardiac massage, or (4) a combination of these.

Puncture or injection is usually done in the right ventricle, the needle being passed directly backward in the fourth or fifth interspace close to the left side of the sternum. When the resistance of the heart is felt at a depth of 4 to 5 cm. the needle is then thrust into the heart wall. If a contraction occurs at this time it will be easily noted by the movement of the needle.

Many substances have been advocated for injection, including strophanthin, camphor, digifolin, caffeine, and adrenalin. The latter, 1 c.c. of a 1:1000 solution, is the drug most frequently used.

Hyman advocates puncture of the right auricle, on the basis that the auricles are more sensitive to stimulation and that *normal* ventricular contractions follow the auricular extrasystoles initiated by the puncture. For this a curved needle is passed through the third interspace close to the right border of the sternum. "The needle is directed toward the midline, so that the curve carries the point under the sternum."

The heart is reached for massage by one of three routes: (1) directly through the chest wall; (2) by abdominal incision; and (3) by incision through the diaphragm from below.

Exposure of the heart by opening the chest is too hazardous and time-consuming, and such a procedure would interfere with the giving of artificial respiration. Massage through the abdomen without opening the diaphragm is the method generally employed, particularly if indicated during an abdominal operation. If the abdomen is not already opened, incision is made in the midline of the epigastrium and the right hand passed below the relaxed diaphragm and just over the liver. (Fig. 8.) Pressure is then made on the heart twenty or thirty times a minute.

By the same abdominal approach the diaphragm may be incised for direct massage, but this operation is difficult and productive of shock. It must be remembered that cessation of the heart beat is usually accompanied by respiratory failure, and *artificial respiration must be carried out at the same time.*

Success will largely depend upon the interval between cessation of the heart beat and the beginning of stimulation, whether by injection or massage. Cerebral anemia results about sixty seconds after the heart stops, but some degree of circulation may be present for a considerable time after examination indicates that the heart has stopped. Therefore, it should always be carried out and continued so long as there is any hope of resuscitation.

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THE TRAUMATIC ABDOMEN

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THE injured abdomen deserves consideration as a clinical entity. It is not so treated in systematic works on surgery, which discuss abdominal injuries not in a single chapter, but in chapters devoted to the abdominal wall and the various viscera. This is inconvenient to the reader, and gives him inadequate information on the causative mechanisms, symptoms and treatment. The excuse for this paper is to call attention to these general features of the subject, which is too vast for detailed treatment in a short article.

For ease of discussion, injuries of the abdomen may be divided into two classes, according to whether they do or do not have external signs of trauma. The second of these is now as common as the first because of the frequency of automobile accidents.

I. INJURIES WITH EXTERNAL SIGNS OF TRAUMA

Those capable of cure are practically limited to gunshot and stab wounds. The treatment of these is a trite subject, but it may not be amiss to emphasize certain facts about it.

1. The immediate fate of the patient depends almost entirely on whether or not a major blood vessel is severed. If this happens he will die before operation is possible; if not, he can probably endure whatever operation is necessary. In a rather extensive experience with these injuries, the writer has never had a death on the table.

2. It is almost certain that a bullet that has traversed any part of the peritoneal cavity in any direction will have pierced the gastrointestinal tract. The only exception is that of an anteroposterior trajectory across the top of the subdiaphragmatic space on the right side.

In twenty cases there was only one in which the bullet had not penetrated the stomach or intestine. In this a small caliber bullet entered the left side of the chest, pierced the diaphragm, and then, its force apparently spent, fell to the bottom of the pelvis.

In case the wound of entry is on the chest, buttocks, perineum or even the thigh, the possibility that the bullet has entered the peritoneal cavity must be kept in mind and not dismissed until excluded by *x*-ray examination. In a case in which the wound of entry was to the left of the perineum, the bullet was located just below the promontory of the sacrum in the midline. At laparotomy it was found to have traversed the bladder and the sigmoid. The wounds of the sigmoid were closed as was the posterior wound in the bladder. The patient made an uneventful recovery.

3. Since the surgeon is confronted by an injury which without immediate operation will almost certainly be fatal, he should perform laparotomy as soon as possible without too much concern over the general condition of the patient. This does not mean that necessary preoperative study and preparation should be omitted. It is essential that a careful physical examination be made and that the course of the bullet be determined either by means of wounds of entry and exit, if the latter is present, or by an *x*-ray study if it is not. A catheterized specimen of urine should be examined and preparation should be made for blood transfusion in the course of the operation. The incision should give ready access to the course of the bullet. The surgeon should proceed systematically

and with deliberation and should not close the abdomen until he has repaired all injuries incompatible with life. This often requires examination of every inch of intestine with perhaps multiple resections thereof, removal of all particulate matter and the arrest of hemorrhage. Bullet wounds of the liver should usually be let alone. Wounds of the pancreas should be closed by suture if they are bleeding. Wounds of the spleen may require its removal if the hemorrhage cannot be controlled by suture. It is unnecessary to make extensive search for a bullet imbedded in the muscles of the back.

Bullet wounds of the kidney require special consideration. They can usually be diagnosed before operation by study of the course of the bullet, by the presence of an effusion of blood in the flank and the usual presence of blood in the urine. If the bullet has entered the peritoneal cavity, it is almost certain to have injured the bowel. It is evident that this injury should be repaired before the injury to the kidney, because otherwise the patient will soon die of peritonitis. After the bowel has been repaired, the opening between the perirenal space and the peritoneal cavity should be closed securely either by suture of the peritoneum or by plugging with omentum. If there is a bullet wound of entry or exit over the kidney, this can be enlarged for tamponade or drainage. It may be convenient to insert this drainage through the wound connecting the abdomen with the perirenal space before closing the abdomen. Unless the bleeding from the kidney is uncontrollable, it is best not to do an immediate nephrectomy.

II. INJURIES WITHOUT EXTERNAL SIGNS OF TRAUMA

These are caused by:

1. Violent compression of the viscera against the spine.

2. A great increase in the intra-abdominal pressure.

3. The forcible introduction of water, air or foreign bodies into the rectum.

The clinician should bear in mind that symptoms which often occur with abdominal injury, as vomiting, ileus and localized pain, may be due to trauma of the chest, spine or extremities.

The most serious injuries within the abdomen may occur without external signs of injury and, in many instances, without, for some time, symptoms of any injury whatsoever. Extensive laceration of the liver or spleen may be unsuspected until the effects of internal hemorrhage are well marked. Rupture of the duodenum or jejunum may not be suspected until hours after the injury which caused it. The same is true of severe injury of the pancreas. Finally, rupture of the diaphragm with passage of various abdominal organs into the chest may not be recognized until after the passage of weeks or months, when an *x*-ray examination, made because of gastrointestinal symptoms, shows its presence. It behooves us, therefore, to examine carefully every patient who has had any accident which conceivably might cause injury to organs within the abdomen. The following case reports illustrate and enforce this dictum:

A boy, aged 10 years, had been knocked off his bicycle by an automobile, one wheel of which passed over his abdomen above the umbilicus. For a number of hours he had shown no signs of injury, and had been permitted to eat. Operation twenty-four hours after the injury revealed a complete transverse rupture of the second portion of the duodenum.

A boy, 8 years old, was seen one hour after the wheel of a school bus had passed across his abdomen. Except for some marks on the skin the child showed no signs of injury. His abdomen was not distended, his pulse and temperature were normal, he was in no great pain. At laparotomy, performed at once, an almost complete division of the jejunum was found.

From these and other experiences of a similar kind, I conclude that laparotomy should be done immediately on any patient who has suffered a violent compression of the abdomen as from the passage over it of

an automobile wheel, no matter how slight the signs of intra-abdominal injury may be.

Trauma of the kind under consideration may injure the stomach.

A man, aged 30, had several ribs on his left side fractured in an automobile accident. He vomited blood and passed dark blood by rectum. He slowly recovered for two weeks. Then he began to have constant severe pain in the left hypochondrium, and frequent emesis of blood and food. He was admitted five weeks after injury, very anemic, but with negative physical findings except for pain on deep pressure on the left hypochondrium. *X*-ray examination revealed a large perforated ulcer of the posterior wall of the fundus of the stomach. At operation this finding was confirmed. It is evident that this injury had been caused by compression of the stomach against the spine.

The pancreas may be crushed in the same manner.

The upper part of the abdomen of a farmer was compressed between the upper bar of a hay rack and the beam across the top of a gangway opening of a barn. Clearance between these objects was 4½ inches. The patient developed an immense collection of fluid in both his greater and lesser peritoneal cavities. The latter was finally drained through the gastrohepatic omentum, and later the necrotic tail of the pancreas was discharged from the wound.

Crushing force, leaving no marks on the abdominal wall, may lacerate the solid viscera or rupture the urinary bladder. A detailed discussion of the diagnosis of these injuries is unnecessary, but the following facts about them should be emphasized:

1. They may give at first no obvious signs of their presence.
2. They can easily be overlooked in a patient having serious injuries in other parts of the body.
3. They can usually be diagnosed if the possibility of their existence is kept in mind.
4. They may be associated with injury to the intestine.
5. Delay in diagnosis may be a far greater peril than exploratory laparotomy.

Increased intra-abdominal pressure is generally admitted to be a rare cause of abdominal injury. Since it compresses the viscera with equal force on all sides, it can damage them only under special conditions. Thus it can rupture a duodenal ulcer having a thin roof attached to a thick ring of scar tissue. The writer observed this in one case. Rupture of the spleen, due solely to increased pressure, has been reported. This must have been caused by compression of the softened organ against the diaphragm.

The most common injury caused by increased intra-abdominal pressure is rupture of the diaphragm. The writer has operated for this injury on six patients in the last two years, and knows of two other cases discovered at autopsy. In all of these the tear in the diaphragm extended outward and slightly backward from the esophageal hiatus. All of the patients were injured in automobile accidents. The tear is evidently caused by sudden great increase in intra-abdominal pressure, due to forward flexion of the body when the diaphragm and muscles of the abdominal wall are strongly contracted. It is, however, often overlooked.

Rupture of the diaphragm is perhaps the only serious abdominal injury which does not require immediate operation. It is not in itself in most cases immediately dangerous to life and it is often associated with injuries in other parts of the body, as concussion of the brain, which render operation dangerous. It is also attended by serious disturbances of intra-thoracic pressure and time should be allowed for the body to adjust itself to these.

Rupture of the pelvic colon by compressed air, blood or solid objects introduced into the rectum is frequent enough to be mentioned. The writer has observed the following instances:

1. Perforation of an amebic ulcer of the rectum by the finger.

II. Perforation of the distal sigmoid: (1) By the proctoscope, (2) by a glass tumbler, (3) rupture of the sigmoid, two cases, by enemas. In both of these the enemas had been injected with great force and the site of perforation, as determined by autopsy, was probably a diverticulum. Both patients when first seen had pelvic abscesses, both had had a sudden severe pain when the enemas were injected. Both could probably have been saved by immediate operation.

CONSIDERATIONS ON OPERATIVE TECHNIQUE

The repair of these injuries requires their exposure to view, and this sometimes means examination of the entire peritoneal cavity. The operative field is nearly always contaminated. Incisions which give ample exposure and withstand infection are desirable. The writer has found two incisions which meet these requirements.

The first, which is used above the level of the umbilicus, extends from the costal border about 2 inches from the midline, vertically downward to the umbilicus. The structures of the abdominal wall are divided in the line of incision down to the aponeurosis of the transversalis muscle. This is opened in line of its fibers, at any level desired, from the midline to the anterior axillary line. This incision gives excellent exposure of either upper quadrant of the abdomen. It can be made, if need be, on both sides. It is easily closed and is practically proof against disruption. To close it, interrupted sutures placed some distance apart to facilitate drainage, should be used. The aponeurosis of the transversalis muscle is the most powerful layer of the abdominal wall above the umbilicus. If its fibers are cut at right angles to their course, it is impossible to unite them securely and a weak wound results, even in the absence of infection.

The second incision, used below the umbilicus, starts about 3 inches to the side of the same, and extends diagonally downwards across the midline to a point about 3 inches to the side of the pubis. The anterior sheaths of the recti are divided in the line of the skin incision, and the recti are retracted from the midline. This is a modified Pfannenstiel incision. It gives complete exposure of the abdomen below the umbilicus and offers much greater resistance to disruption than a simple midline incision.

In case exposure of one upper quadrant and one or both lower quadrants is needed, then both of these incisions, rather than a single long incision, should be used.

The peritoneum can resist almost an unlimited number of bacteria if they are not associated with gross particulate matter. It is therefore necessary to remove blood clots and bowel contents with scrupulous care. Fortunately the latter usually remain not far from the perforation of the bowel. An efficient suction apparatus is an indispensable help. Drainage should seldom be used except in some cases in the abdominal wall. Finally in this field, nothing short of adequate surgery is enough. The patient may not survive it, but he will certainly not survive the lack of it.

APPENDICITIS*

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ACUTE inflammation of the vermiform appendix is one of the most important surgical emergencies because of its frequency, its amenability to early treatment, and the danger it engenders with improper care. In the United States appendicitis exacts an annual toll of 20,000 lives which is one fatality from appendicitis every twenty-six minutes. Eighty-two per cent of these deaths result from generalized peritonitis, 10 per cent from peritoneal abscesses, and 8 per cent from various other complications. These figures are particularly important when one considers that at least 75 per cent of these fatalities are preventable.

Etiology. The etiology of acute appendiceal disease is not known. There are a number of theories which have been suggested to account for its occurrence. Until relatively recently, acute appendiceal disease was considered by most clinicians to be an acute inflammatory process, and the generally accepted theory concerning its causation was that of Aschoff[1] in which the inflammatory process supposedly began at the bottom of an appendiceal crypt, resulting in infection and inflammatory involvement of the appendiceal wall. Recently, Carabba and Baccarani[2] reported an investigation which tends to support the bacterial inflammatory process. They injected *Staphylococcus albus* into the marginal veins of rabbits and sacrificed the animals at various intervals. Histologic sections revealed the presence of the injected bacteria in both the appendix and the tonsils. As early as 1904 Van Zwalenburg[3] called attention to a mechanical factor, that is, an obstructive lesion, in producing an appendiceal disease. It was not until the publications of Wilkie,[4] however, that obstructive appendiceal disease was considered of much importance. At the present time it is well known that one must differentiate between the two types of appendiceal disease, that is, an inflammatory lesion, or a true appendicitis, and an obstructive lesion, the so-called obstructive appendiceal disease.

Whereas Wangensteen and Bowers,[5] on the basis of their investigations, are of the opinion that most if not all cases of inflammatory lesions of the appendix are the result of a primary obstruction, probably not all cases can be classified as such. Although one can never say in an individual case or group of cases that an antecedent obstruction was not responsible for initiating the inflammatory process, the occurrence of appendicitis in young individuals during the course of acute upper respiratory infections is suggestive of a pure inflammatory lesion, and in these cases at least the obstruction plays little or no rôle.

Wangensteen and Bowers, after extensive animal experimentation, are of the opinion that an increase in intraluminary pressure is of paramount importance in the production of appendiceal inflammation. They found that when the intra-appendiceal pressure was as high as from 6 cm. to 15 cm. of water and was maintained for six to eighteen hours, acute inflammation of the appendiceal wall occurred which would progress to gangrene. The pathogenesis, as outlined by Bowers,[6] is as follows: "The lumen of the appendix becomes occluded by a slowly enlarging fecalith or by some other mechanism and a closed loop is thus formed. Peristalsis is stimulated as the

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appendix attempts to overcome the obstruction, and the patient notices cramp-like pains in the abdomen. Peristalsis together with the obstruction acts as a secretory stimulus, and the lumen gradually fills with fluid from this source and also from the action of bacteria on its contents. The distention causes pressure on the terminations of the sympathetic nerves, and the patient experiences pain of a more or less constant nature, usually referred to the umbilical region. As distention increases the capillaries and venules become occluded, whereas in the arterioles blood continues to be pumped in at systolic pressure. Vascular congestion follows, and edema and diapedesis of leucocytes begin. The distention has now reached such proportions that reflex nausea and vomiting occur, and the patient has such severe pain that it is recognized as coming from the right lower quadrant of the abdomen. Distention progresses, and inflammatory reaction increases until the terminations of the visceral afferent nerves are killed by pressure or by anoxemia. The pain then becomes less. The distention now has completely shut off the capillaries and smaller veins so that thrombosis occurs. The antemesenteric border has the poorest blood supply. Here, diamond-shaped infarcts develop first. The reaction has now reached the serosa so that the patient experiences pain from peritoneal source, and rebound tenderness with rigidity can be elicited. As more blood is pumped into the appendix, the smaller vessels rupture and hemorrhage occurs. By this time the walls distal to the obstruction are thinned by distention and the mucosa has become ulcerated and destroyed as a result of pressure necrosis. Fever, rapid pulse, and leucocytosis have developed as a consequence of absorption of dead tissue products. As soon as necrosis of tissue appears, bacteria may enter the tissues. If the appendix is not able to overcome the obstructing mechanism, perforation eventuates, usually through one of the infarcted areas on the antemesenteric border. At this stage the patient experiences relief of pain due to release of pressure."

In 17 per cent of appendicitis cases at the Charity Hospital in New Orleans studied by Mahorner and Vincent[7] a definite obstructon of the appendix was demonstrable. Although there may be some controversy concerning the relative frequency of the existence of infection and obstruction in appendiceal disease, there is little question concerning the importance of differentiation between these two types and the possible prognostic factor which they may have. This will be discussed more in detail under prognosis and treatment.

Incidence. Whereas appendicitis may occur at any age, it is largely a disease of young adult life, occurring most frequently in the second and third decades. In the Charity Hospital cases reported by Mahorner and Vincent[7] 41 per cent occurred between the ages of 10 and 20 and the mean age was 19 years. In Bowers'[6] series of cases the average age of patients with acute appendicitis was 22 years. The importance of appendicitis at the two extremes of life, particularly as regards the prognosis, has been emphasized by Beekman,[8] and Maes, Boyce and McFetridge.[9]

Sex. Males are affected slightly more frequently than females, although there is so little difference that it is probably of little consequence.

Pathology. The gross pathologic lesion in acute appendicitis varies considerably. In those cases in which the condition is predominantly of the inflammatory type, there is marked thickening of the appendiceal wall with considerable reaction of the serosal covering. According to Bowers[6] the primary lesion in appendicitis results from the presence of the fecalith obstructing the appendiceal lumen, and at the site of contact of the fecalith with the appendiceal mucosa there occurs a denudation of the mucosa with exposure of the submucosa to the appendiceal lumen. This permits the organisms contained within the lumen of the appendix to penetrate into the submucosa. Once infection has gained

entrance to the submucosa the inflammatory reaction becomes marked because, as emphasized by Bowers, most of the blood vessels are located in this layer. This reaction, consisting of both cellular and fluid exudation, is responsible for the increase in thickness of the appendiceal wall.

The inflammatory process may extend through the wall of the appendix, involving the musculature and also the serosa, although many times the serosa is involved earlier than the appendiceal musculature. As a result of the inflammatory involvement of the submucosa in which most of the vessels are located, there occurs thrombosis of the vessels with resulting gangrene. In those cases in which the lesion is primarily an obstructive one, because of distention, intramural strangulation of the appendiceal vessels can occur with early gangrene before the inflammatory process has extended throughout the wall of the appendix. This is of importance because perforation can and is likely to occur before walling off by serosal protective adhesions can take place. This results in widespread contamination of the free peritoneal cavity. On the other hand, an inflammatory lesion of the appendix, which may even progress to gangrene, everything else being equal, is less likely to result in contamination of the general peritoneal cavity because the localizing inflammatory reaction of the serosal covering of the appendix tends to prevent dissemination of the infection. Maes, Boyce, and McFetridge[10] have emphasized the importance of the obstructive phenomenon in elderly individuals whose vascular system is already occluded.

It is a well known fact that catharsis greatly increases the risk in cases of appendicitis and this is undoubtedly due to the danger of rupturing a diseased viscus which is already inflamed by increasing the intra-enteric pressure. Certainly the change in the intra-appendiceal pressure further interferes with the blood supply to the wall of the viscus, thus further enhancing its tendency toward rupture. Bower et al.[11] have shown that the mortality rate varies proportionately with the administration of laxatives. In collected cases of peritonitis complicating acute appendicitis, the mortality was 10 per cent in patients who had taken no cathartics, it was 22 per cent when one, and 29 per cent when more than one had been taken. They believe that the mortality is increased when a purgative is taken shortly after the onset of pain. In the Charity Hospital cases of acute appendicitis reported by Mahorner and Vincent,[7] of 145 who had received catharsis 11 per cent died, and of sixty-six receiving no cathartics 1.5 per cent died. Forty-five per cent of the patients admitted with generalized peritonitis stated that one or more cathartics had been administered. Thirty-seven per cent of these died.

Clinical Manifestations. The most important symptom in acute appendicitis is abdominal pain, which in the beginning is rather diffuse and located either in the epigastrium or in the region of the umbilicus. This is undoubtedly due to stimulation of the splanchnic nerves, the pain being referred to the region of the celiac plexus. The pain is either constant (stomach ache) or colicky. The latter is suggestive of an obstructive lesion. Colicky pain is particularly significant because of the greater danger of obstructive appendiceal disease. Later the pain becomes localized in the right lower quadrant and is undoubtedly due to the extension of the inflammatory process through the wall of the appendix to the serosa with resultant involvement of the parietal peritoneum. According to Burger and Torbert,[12] approximately 93 per cent of their patients with acute appendicitis had localized pain. Bowers[6] found that in his series of cases colicky pain was present in 31 per cent and constant pain in 56 per cent.

Nausea and vomiting are frequent manifestations and usually follow the onset of pain. Nausea was present in 64.5 per cent of Burger and Torbert's[12] cases and in 90 per cent of Bowers'[6] cases. Vomiting is less frequently present than is nausea. It

was present in only 48.1 per cent of Burger and Torbert's cases and in 60 per cent of Bowers' cases.

As early emphasized by John B. Murphy,[13] the subsidence of pain may be a bad omen and may be the result of a numbing of the nerves as a result of gangrene. This has recently been emphasized by Bower[14] and Bowers.[6] The relief of pain, however, may not necessarily indicate a destruction of the sensory nerves, but may be occasioned by the relief of the obstructing lesion such as the passage of the obstructing fecalith out of the appendix into the fecal lumen. The prompt disappearance of the pain and the subsequent subsidence of all evidences of appendiceal disease are undoubtedly accounted for in this way in many cases.

In addition to the pain, nausea, and vomiting there may be irregularity in bowel habits. Constipation or diarrhea may be present. In Bowers' series of cases constipation was present in 13 per cent.

Maes et al.,[9] and Burger and Torbert[12] have emphasized the bizarre manifestations which acute appendicitis may have in young children. In two of Burger and Torbert's cases the onset of the condition was accompanied by convulsions, and in two other cases there was a violent chill.

On physical examination tenderness is the most prominent and most important diagnostic manifestation. With few exceptions it can be elicited and is of diagnostic importance in localizing the lesion. In Bowers' series of cases it was present in 95.5 per cent. There was little difference in the obstructive and non-obstructive cases as regards the presence of tenderness. Burger and Torbert have emphasized that occasionally, particularly in obese individuals, there may be an absence of positive physical findings. This is particularly true if the appendix is covered over by a thick, fat omentum. In determining the presence or absence of tenderness it is of importance to localize the maximum point of tenderness. Whereas this is considered by most individuals to be over McBurney's point, in our experience the maximum point of tenderness is over Lanz' point in approximately 70 per cent of cases. Lanz' point is at the junction of the right and middle thirds on a line connecting the two anterior-superior iliac spines.

Of great importance is the performance of a rectal examination, because frequently the tip or even the entire appendix lies in the true pelvis, and can be best palpated through the rectum. This is particularly true in children in whom a rectal examination is of comparatively greater importance because of the ability to insert the examining finger for a relatively longer distance. Rebound tenderness is of importance in the diagnosis of an acute inflammatory process of the abdomen and is indicative of involvement of the peritoneum. Whereas it is present in most cases of acute appendicitis, its presence does not necessarily indicate appendiceal disease.

An important finding in acute appendicitis is fever. However, characteristically, the patient with an uncomplicated appendicitis does not have hyperpyrexia. Generally the temperature varies from 99° to 101°F., and it can be accepted that an individual with hyperpyrexia, unless that individual is a child, either does not have appendicitis or has some complicating lesion. The presence of chills associated with the fever is even more suggestive of a complication of appendicitis such as involvement of the venous radicles, with the possibility of extension into the portal vein. The pulse rate is similarly increased and is in proportion to the elevation of temperature.

Of importance in the diagnosis is the blood count. Characteristically, there is a leucocytosis with an increase in the polymorphonuclear leucocytes. This, as in the case of the temperature, is not excessive, the average ranging from 10,000 to 12,000 per cu. mm. A patient with hyperpyrexia and with a very high leucocyte count is likely not to have appendicitis. On the other hand, we have seen patients, particularly children, with counts as high as 20,000 with obstructive and suppurative

lesions of the appendix in which the exudate was under considerable tension. The disproportionate increase in the polymorphonuclear leucocytes is of importance both from diagnostic and prognostic standpoints. Everything else being equal, the higher the polymorphonuclear leucocytic count, the more severe the infection in spite of the total blood count. In the severe infection there is a shift to the left in the Schilling hemogram. Whereas the presence of an increased leucocytic count is confirmatory in a suspected case of appendicitis, we believe as did the late A. J. Ochsner,[15,16,17,18] that its absence is of no significance. He frequently stated and also practiced that a white blood count should always be made, but no attention should be paid to it provided the other manifestations indicated appendicular disease.

Diagnosis. The diagnosis of acute appendicitis is of paramount importance, because if it can be made early before the infection has spread beyond the confines of the appendix and the removal of the diseased viscus accomplished, the mortality rate from appendicitis could be almost negligible. Although the textbook picture of acute appendicitis is quite clear-cut, there are few conditions which offer greater difficulty in making a correct diagnosis.

No one desires to operate unnecessarily, but this is one condition in which operation is justified in suspicious cases. Previously, we were critical of any individual who operated for acute appendicitis and found a normal appendix. At present, however, we believe that if one is honest and thorough in his investigation and cannot exclude the possibility of the existence of an acute appendicitis, immediate laparotomy and appendectomy should be done in those cases in which the infection is apparently confined to the appendix. *Although occasionally the removal of an appendix for some other condition will occur and this is admittedly undesirable, the risk from an unnecessary laparotomy associated with an appendectomy is minimal compared with the risk of overlooking a diseased appendix and permitting it to perforate.* Although the authors take this rather radical stand concerning the need of early operation in all suspected cases of acute appendicitis, and even though they feel that such a condition as chronic appendicitis does exist, they are of the opinion that *extirpation of an appendix for chronic appendicitis should be done only after exhaustive search has failed to reveal other causes of the symptoms.*

It is imperative to differentiate acute appendicitis from acute pelvic disease, particularly because in the former immediate operation is necessary and in the latter conservative treatment is indicated. In an individual case, however, in which one cannot differentiate satisfactorily on physical findings, laparotomy should be performed, although generally a patient with acute salpingitis has a higher temperature, a higher leucocyte count, appears much sicker, and has tenderness over and limited to the involved adnexa. In case of doubt, laparotomy should be done in order not to overlook a possible appendiceal process. In the event the lesion proves to be salpingitis, closure of the abdomen with the institution of conservative therapy should be done.

Particularly in children, mesenteric lymphadenitis should be considered. Here, too, the temperature is likely to be higher and the leucocyte count greater than in a case of appendicitis. Also of importance is the presence of tenderness along the root of the mesentery, that is, along a line extending from the region of McBurney's point obliquely upward and to the left, passing just above the umbilicus. As acute mesenteric lymphadenitis in children is frequently associated with appendicitis, we feel that many of these patients should be operated upon and the appendix removed. We have observed many cases in which the manifestations of the mesenteric lymphadenitis have subsided completely following appendectomy.

Acute urinary infections, particularly pyelitis or ureteral calculi, must be ex-

cluded, since not infrequently the two conditions give similar manifestations. An inflammatory process involving the ureter may give identical symptoms to an inflammatory process in an overlying appendix. Conversely, a diseased appendix by producing an acute inflammation of the ureter may give rise to symptoms referable to rhe urinary system and even result in hematuria.

That acute suppurative processes within the appendix can occur without characteristic evidence is shown by the statistics of Shelly,[19] who found in 2,065 consecutive incidental appendectomies, acute appendicitis and suppuration without objective or subjective evidence, in 1.7 per cent of the cases. A case with bizarre manifestations is reported by Barber[20] whose patient had an acute mania. Within three weeks following removal of a gangrenous appendix, there was dramatic recovery of the patient's mentality and a return to normal.

Atypical manifestations are likely to occur at the two extremes of life. McLaughton and Davis[21] have emphasized that because of the large amount of lymphoid tissue in the appendix and the thinness of its wall in children, perforation occurs early and is likely to progress rapidly to generalized peritonitis because the underdeveloped omentum offers little resistance to the invading micro-organisms. Deaver and Martin[22] state that it is not uncommon to find a perforated appendix in a child who has been sick less than twelve hours and that appendicitis following gastroenteritis is not only difficult to diagnose, but is likely to be fulminating in character. Appendicitis in the aged also offers considerable difficulty in diagnosis. The abdominal pain and tenderness are frequently less marked than in younger persons. As suggested by Holman,[23] the symptoms in elderly persons with appendicitis frequently suggest intestinal obstruction.

Treatment. As mentioned above, there is only one treatment of acute appendicitis and that is immediate extirpation of the involved viscus before extension has occurred beyond its confines. If this is done, the mortality rate from appendicitis will become virtually negligible. In cases of uncomplicated acute appendicitis in which the infection has not extended beyond the confines of the appendix immediate appendectomy should be done. We believe that a muscle-splitting incision, either the McBurney[24] or the Rockey[25]-Davis,[26] should be used. Before the removal of the appendix the abdominal wound edges should be protected by placing moist cloths or rubber sheets into the peritoneal cavity and allowing them to protrude from the abdominal wound. In this way the abdominal wall, which is more susceptible to infection than the peritoneum, is protected from possible contamination.

As previously emphasized by Ochsner and Lilly,[27] the method of handling the appendiceal stump is of paramount importance, in order to prevent sequelae. Of the three techniques of treating the appendiceal stump, (1) simple ligation, (2) ligation and inversion, and (3) inversion without ligation, inversion without ligation is the only one which is surgically sound. Simple ligation is particularly dangerous because of the possibility of the stump blowing out, a complication which we have seen several times. Ligation and inversion is also dangerous because the contaminated ligated stump is buried in a closed cavity which may give rise to a localized suppurative process and peritonitis by rupture into the peritoneal cavity. The inversion without ligation technique is surgically sound and is not accompanied by sequelae.

The technique of appendectomy which we have employed for years was previously described by Ochsner and Lilly[27] as follows:

"Before proceeding to the removal of the appendix, moist cloths are inserted around the wound down to and into the peritoneal cavity, completely walling off the abdominal wall from the appendix. In this way contamination of the abdominal wall, which has little resistance to infection, is prevented. Traction is applied to the tip of

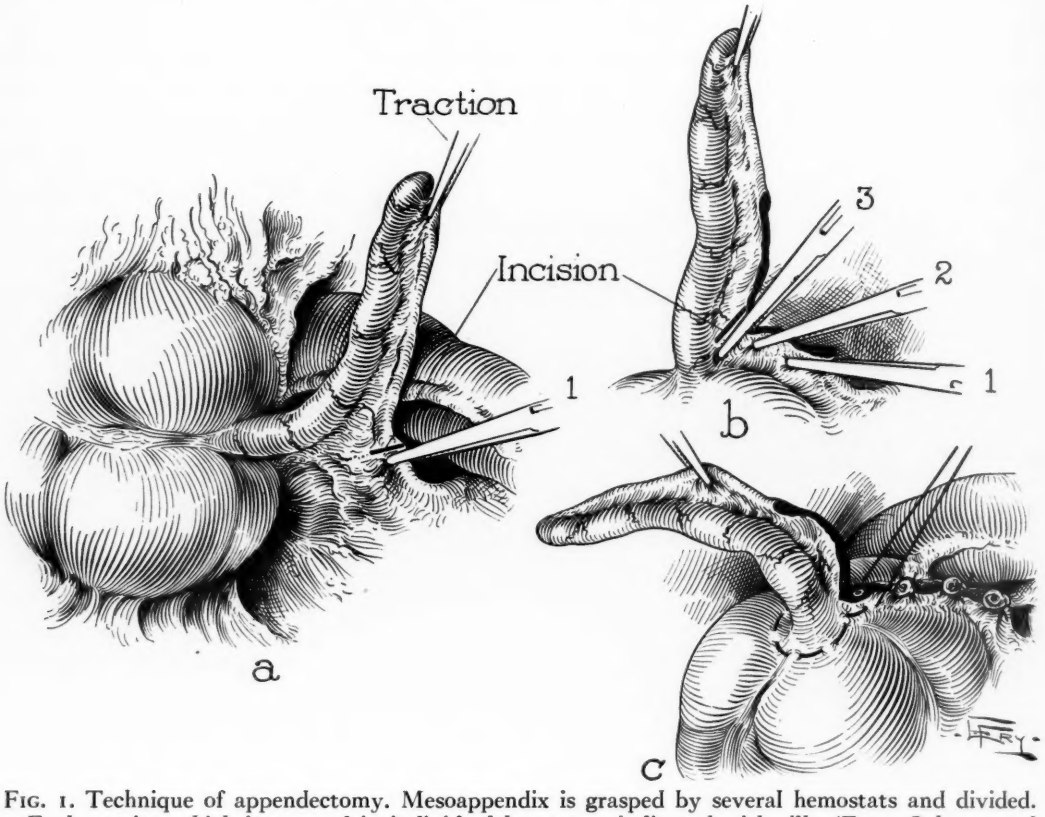

Fig. 1. Technique of appendectomy. Mesoappendix is grasped by several hemostats and divided. Each portion which is grasped in individual hemostats is ligated with silk. (From Ochsner and Lilly, in *Surgery*, 2: 532, 1937.)

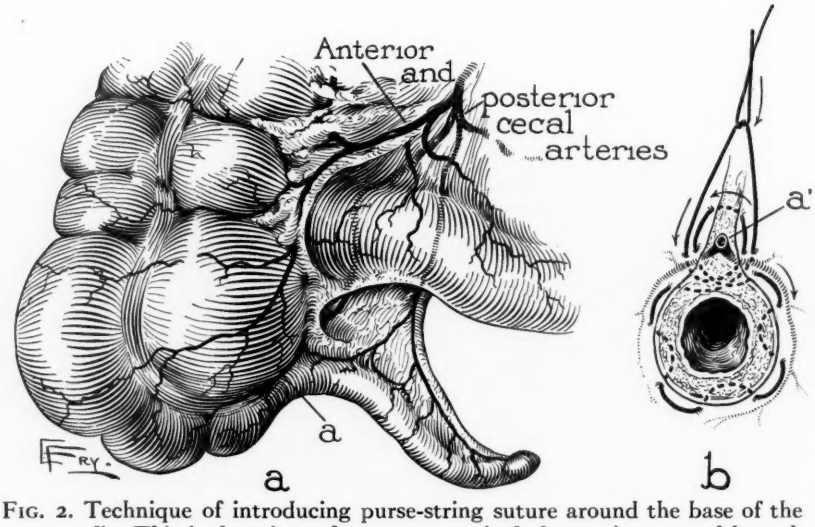

Fig. 2. Technique of introducing purse-string suture around the base of the appendix. This is done in such a way as to include any intramural branch of the appendiceal artery. *b*, the purse-string suture begins at the mesenteric attachment passing into the submucosa. It emerges on the opposite side of the mesenteric attachment to be reintroduced on the original side. In this way a loop is made around any intramural branch of the appendiceal artery. The purse-string is then continued around the base of the appendix in the conventional manner. (From Ochsner and Lilly, in *Surgery*, 2: 532, 1937.)

the appendix by grasping the mesoappendix with a hemostat and lifting it upward. This affords an adequate exposure of the mesoappendix, which is clamped, divided, and ligated with fine silk ligatures. (Fig. 1.) A purse-string suture of No. 1 silk on an atraumatic needle is then introduced in such a way as to include an intramural branch of the appendicular artery. This is accomplished by beginning the purse-string suture on one side of the mesoappendix so that it passes down to and includes the submucosa and emerges from the opposite side of the mesoappendix. The suture is reinserted in the same manner, forming a loop around the mesenteric portion of the cecal wall and encircling any intramural branch of the appendicular artery. (Fig. 2.) This loop suture is tightened to occlude any arterial branch which may be present, and the purse-string suture is continued around the cecum in the conventional manner. After the introduction of the purse-string suture, three Ochsner clamps are applied to the base of the appendix, and the area is walled off with moist gauze packs to avoid any possibility of contamination or injury to the surrounding structures. The appendix is divided by means of the thermocautery between the distal two clamps. (Fig. 3A.) By means of a sponge, the cauterized portion is wiped away from the middle forceps. The middle clamp is then removed and the crushed tip of the stump thus exposed is grasped with a pair of plain tissue forceps before

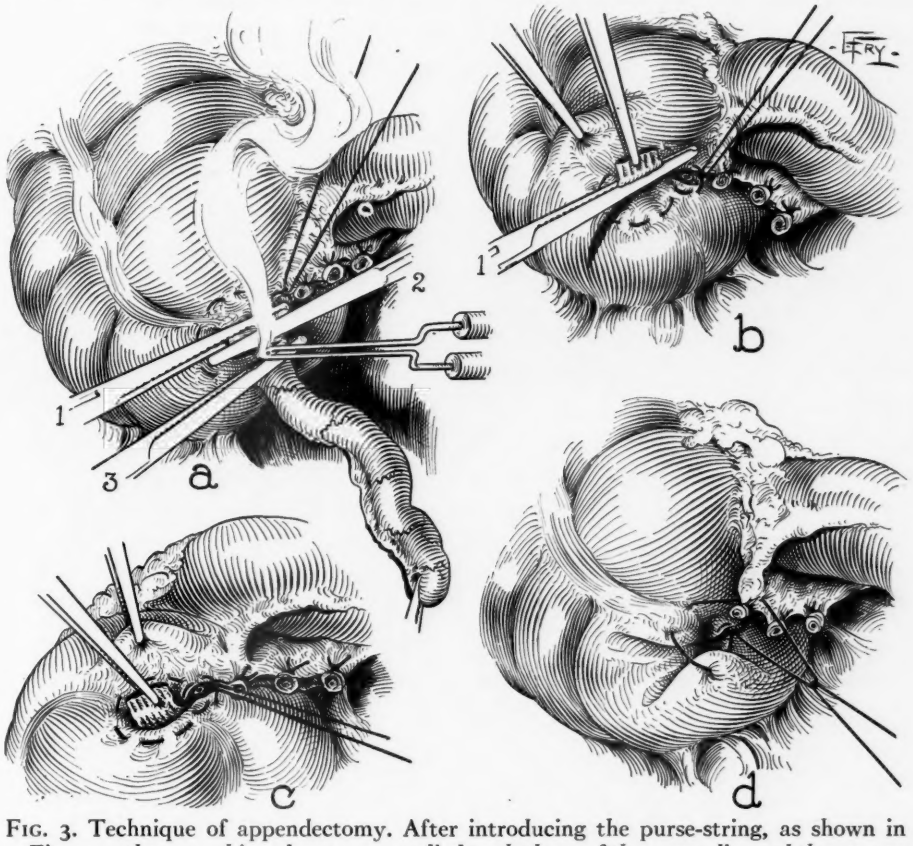

Fig. 3. Technique of appendectomy. After introducing the purse-string, as shown in Figure 2, three crushing clamps are applied to the base of the appendix, and the appendix divided between the upper and the middle clamp leaving two clamps on the appendiceal stump. One of these clamps is removed, permitting the crushed portion to be grasped by means of smooth forceps (*b*) before the last clamp is removed. This prevents any possible contamination during this manipulation. The last clamp is removed (*c*) and the non-ligated stump is inverted into the lumen of the cecum, and the purse-string suture tightened. The inverted area is further inverted by several Lembert sutures (*d*). (From Ochsner and Lilly, in *Surgery*, 2: 532, 1937.)

removing the third crushing clamp. (Fig. 3B.) Traction is then made on the fixed end of the purse-string suture by pulling upward on this side of the suture, and traction is also made at a point on the cecal wall opposite this point by catching a tenial band with a pair of toothed tissue forceps and lifting it upward. (Fig. 3C.) The remaining Ochsner clamp is then removed, and the stump of the appendix is inverted through the purse-string suture into the cecal lumen by pushing it downward with the smooth tissue forceps with which it has been held (Fig. 3C.) The purse-string suture is drawn tightly as the tissue forceps are gently freed and withdrawn. The site of the inverted stump is carefully compressed with a sponge and the purse-string suture is tied. The site of the inversion is then reinforced by installing several Lembert sutures over the area of inversion and by suturing the stump of the mesoappendix over this same area. (Fig. 3D.) In this way the hemorrhage from an intramural branch of the appendicular artery is prevented by a loop in the purse-string suture around it; spillage during inversion is prevented by the use of three crushing clamps, which permit grasping of the crushed appendiceal stump before the last clamp is removed; and subsequent peritoneal infection is prevented because the infected stump is inverted into the cecal lumen and is not buried within the wall of the cecum."

In case contamination occurs, due to rupture of a gangrenous appendix during appendectomy we use the coli-bactragen of Steinberg[28] and have found it effective in preventing peritonitis. This, however, is not recommended when generalized involvement of the peritoneum is already present.

Unfortunately, many cases of appendicitis are not seen at a time in which the appendix can be removed before extension has occurred. It is in these cases that the mortality rate is high, and it is also in these cases that other forms of therapy can and should be used. Whereas the late A. J. Ochsner[15,16,17] described the delayed treatment of appendicitis, he did not treat acute appendicitis conservatively. He was just as ardent an advocate of the immediate extirpation of an acutely inflamed appendix as any surgeon today. He did emphasize, however, the desirability of treating conservatively certain cases with complicating peritonitis in which the peritonitis was the most important factor. Although at the present time there are many who believe that all cases of appendicitis, irrespective of the time which they are seen and irrespective of the presence or absence of complications should be operated upon immediately, there is a gradual trend toward a more rational conception of the treatment of the complications of appendicitis, and the results obtained justify this change.

Stanton[29] reports 113 cases of acute appendicitis complicated by peritonitis, with a combined mortality rate of 17.6 per cent. Of thirty-one treated by immediate operation, thirteen died (forty-two per cent), whereas of eighty-two patients who were treated conservatively and later operated upon, only seven died (8.5 per cent). Of importance also is the fact that the more desperately ill patients were treated conservatively.

Coller and Potter[30] estimate an average mortality of 28 per cent for immediate operation in generalized peritonitis, with variations from 15 to 65 per cent. After adopting the policy of deferred operations the fatalities in their series of eighty-five cases dropped to 9.3 per cent. Young[31] finds the death rate approximately the same in each of his two groups; however, he adds that six of the seven fatalities occurring in the conservatively treated group of fifty-five (mortality 12.7 per cent) were patients admitted in extremis. With these excluded, his delayed surgery mortality would be 2 per cent as compared to the 12.6 per cent mortality encountered in the 333 treated by immediate operation.

Guerry,[32] in 1926, had a mortality of 8.2 per cent in eighty-five cases of peritoni-

tis treated by immediate operation as compared to 1.6 per cent in 123 in which surgical intervention was delayed. In 1932, this same author[33] was able to reduce the mortality in his 128 delayed cases to 1.5 per cent, while in the series of ninety-three operated upon at once, the death rate rose to 10.75 per cent. Two years later,[34] the rates were 1.4 per cent in the delayed group of 135, and 10.6 per cent in ninety-four patients upon whom immediate operation was done.

Walker's[35] seventy-seven cases operated upon at once had a mortality of 42 per cent, while delayed surgery in thirty instances reduced the fatal outcome to 13 per cent. Adams and Bancroft[36] have employed delayed surgical procedures beneficially in children. Comparing the results published by Tasche[37] in the same hospital, covering the decade 1920–1929, during which time immediate operation was practiced, they find a mortality reduction from 10.14 per cent to 4.5 per cent resulting from conservative treatment with deferred surgery.

Gardner[38] divided his series of 248 cases of appendiceal peritonitis into two periods, viz., when delayed operation was used only occasionally, and when it was relied upon consistently except in children with generalized peritonitis. The mortality fell from 18 per cent to 8.7 per cent after adoption of the delayed operation method of treatment.

The rationale of the conservative treatment of appendiceal peritonitis is based upon the fact that trauma to the peritoneum and other serous membranes results in marked exudation of fluid rich in fibrin, which if left alone will wall off the originating infection and limit its extension. The injudicious operation with the breaking down of peritoneal adhesions tends to disseminate the localizing infection and produce a generalized peritonitis.

There is probably nothing more difficult than the conservative treatment of appendiceal peritonitis, and we are thoroughly in accord with Nuttall[39] that this method of therapy is a great strain on the surgeon and the house staff. We also believe that it is no method of therapy to be employed by the occasional operator who would do far better by operating immediately upon all cases of appendicitis, irrespective of the time they are seen. There is nothing that requires more careful supervision and greater surgical judgment than the conservative treatment of appendiceal peritonitis. The increased strain on the surgeon and his house staff is largely due to the fact that these patients live longer than the patients who are operated upon immediately and live long enough to worry the surgeon over a longer period of time. *It is far better, however, to have a living patient who may develop a complication but who ultimately will recover than to have that individual die within a short period of time after the operative procedure.*

If the patient is seen shortly after rupture and if there is no evidence of localization, immediate operation should be done, because the conservative treatment of appendiceal peritonitis is indicated only in those cases in which beginning localization has occurred. Where there is difficulty in differentiating between the case which is localizing and that in which there is continued spreading of the peritonitis, laparotomy should be done and, if at the operation a localized lesion is found, one should not hesitate to close the abdominal wound without appendectomy. This takes considerable fortitude because of the criticism arising from performing a laparotomy in a case of an acute appendicitis without removing the appendix. By the institution of adequate conservative therapy, however, one will be amply repaid.

In children, localization is less likely to occur than in adults because of the massive contamination of the peritoneal cavity and the relatively small omentum. Because of this, we feel that all children suspected of having peritonitis, and without definite localization, should be operated upon immediately. If the appendix is walled off, it is left alone; if it is not, appendectomy

is done. The advantage of this is shown by the two following cases:

A 9-year old girl in whom advanced acute appendicitis or early rupture had to be considered was operated upon. Upon opening the peritoneal cavity, a large amount fluid exudate and intestinal contents was encountered. The appendix was free, with no evidence of any walling-off, and was draining its contents through a perforation in its midportion. The appendix was removed, and the patient recovered.

Another case of peritonitis in a child of the same age was treated conservatively with a fatal outcome. At necropsy no localization of process was found. A perforation in the appendix was still patent and draining intestinal contents.

The conservative treatment of appendiceal peritonitis consists of placing the gastrointestinal tract at complete rest and producing functional inactivity. The patient is placed in Fowler's position, permitting gravitation of the peritoneal exudate into the cul-de-sac, where it can be more readily watched and where a suppurative process can be more easily drained. In all cases there is an associated ileus of the adynamic variety. In order to combat this, an indwelling duodenal catheter should be introduced and continuous suction applied. This removes the secretions which stagnate in the stomach and duodenum and prevents nausea and vomiting.

Large doses of morphine are given in order to increase the intestinal tone. As originally used in the treatment of typhlitis, large doses of opium were thought to splint the bowel. It is now known, as a result of the investigations of Plant and Miller,[40] Orr and Carlson,[41] and Ochsner, Gage, and Cutting[42] that morphine exerts a markedly stimulating effect on intestinal tone. Generally, in the case of adults ¼ to ⅓ gr. of morphine is given every three to four hours.

Oxygen is administered either by means of a nasal catheter or by the Lombard mask. Prior to the fundamental investigations of Fine et al.[43] we used oxygen because we felt that it was undesirable to produce anoxemia by the depressing effect of morphine on the respiratory center. These authors demonstrated, however, that oxygen exerts a beneficial decompressive effect on gut and should be used in all cases of ileus.

Because the patients lose considerable fluid insensibly and through the stomach and duodenum, they require relatively large amounts of fluids and electrolytes. They should receive infusions of saline and glucose, the amount varying from two to four liters daily. Careful chemical examinations of the blood, particularly as regards the non-protein nitrogen, blood chloride, and CO_2 combining power should be made. Heat is applied to the abdomen either by means of electric pads or a heat tent. Heat is of benefit in the treatment of the adynamic ileus because application of heat to the abdominal parietes produces vasodilatation in this area and a concomitant vasoconstriction in the splanchnic area. This is associated with a decrease in the intestinal secretion and an increase in intestinal tone.

Careful examination of the patient should be made daily in order to detect the possibility of development of localized suppurative processes in various portions of the peritoneal cavity. The sites at which localization is likely to occur are (1) the cul-de-sac of Douglas; (2) the right iliac fossa; (3) the subphrenic area, both above and below the liver; and (4) on the left side. These will be discussed more in detail under complications. In order to detect the possibility of localizing infections in these areas, repeated rectal examinations should be made. Careful examination of the abdomen should be made, paying particular attention to tenderness and rigidity in the right iliac fossa, over the right twelfth rib, along the right costal margin, and in the left iliac fossa.

Complications. The intraperitoneal localizations which were enumerated above are the most frequent complications of acute appendicitis. In addition to these is a

relatively infrequent complication, but one which is of importance, viz., portal thrombophlebitis or pylephlebitis.

Whereas localization of intraperitoneal infections occurs not infrequently in cases of peritonitis, relatively few of them go on to suppuration. As previously emphasized (Ochsner[44]), the incidence of suppuration in the localized intraperitoneal infections is approximately 25 per cent. Those cases which subside are likely to be overlooked unless one considers their possibility and is on the lookout for them. Cul-de-sac infections are diagnosed by the finding of a bulging in the anterior wall of the rectum on rectal examination. This is due to the presence of fluid in the cul-de-sac of Douglas. Of diagnostic importance is the relaxation of the anal sphincter, which normally offers considerable resistance to the examining finger. The patient may complain of a sense of fullness in the rectum and may have an urgency to defecate and urinate due to the associated proctitis and cystitis. On examination, in addition to the bulging in the anterior wall of the rectum, there is not infrequently a succulence of the mucosa on the anterior rectal wall due to the edema in this area. Under conservative therapy, consisting of the treatment outlined for general peritonitis and also application of heat to the rectum, most cul-de-sac infections subside spontaneously. In approximately 25 per cent of instances suppuration occurs, and when it does, incision and drainage must be done. Suppuration of a cul-de-sac infection is indicated by the persistence of the systemic manifestations of infection, such as fever and leucocytosis, and an area of softening in the indurated bulging mass on the anterior wall of the rectum. This is best compared to a rotten spot in an otherwise normal apple. If one were to move his finger along the surface of the apple, which offers considerable resistance to the palpating finger, and then palpate the rotten area, one could appreciate the sensation imparted by a cul-de-sac infection which has undergone suppuration. The soft area is the location at which pointing into the rectum has occurred.

Incision and drainage of a cul-de-sac abscess is best accomplished through the rectum in both sexes. Generally, no anesthesia is necessary because of the marked relaxation of the anal sphincter. After careful dilatation of the sphincter a large needle which is attached to a syringe is introduced into the soft area described above. (Fig. 4.) One need have no fear of penetrating loops of bowel, because they, with their gaseous contents, float above the fluid. After pus has been aspirated from the abscess cavity, an incision is made longitudinally in the anterior rectal wall along the aspirating needle and the abscess opened widely by means of blunt forceps. A fenestrated rubber tube is inserted into the abscess cavity and conducted out through the rectum.

The second most frequent complication of appendiceal peritonitis is ileocecal infection. Many cases of appendicitis with rupture which have become localized develop a peritonitis in the region of the ileocecum and do not progress to a generalized peritonitis. The manifestations are the same in both. There is a mass which is present in the right iliac fossa, usually in the region of McBurney's point. There is marked tenderness in this area with muscular rigidity. There are also systemic signs of infection, such as fever and leucocytosis. Here, as in other portions of the peritoneal cavity, most of these conditions will subside spontaneously and not progress to suppuration. In only about 25 per cent of instances does suppuration occur. In cases in which the localized infection does not progress to suppuration the mass which is palpable is usually made up of loops of bowel and the omentum around the perforated appendix. In the beginning before suppuration occurs, the conservative treatment for peritonitis should be instituted. If the systemic manifestations of infection do not subside, if the leucocyte count increases, and if the temperature becomes hectic, one may conclude that

suppuration has occurred and that incision and drainage are necessary. In draining such an abscess, it is imperative that an uninvolved portion of the peritoneum is not contaminated. This is generally accomplished by making an oblique incision lateral to or on the lateral aspect of the mass and approaching the mass extraperitoneally. (Fig. 5.) If the free peritoneal cavity is opened, it should be closed and an

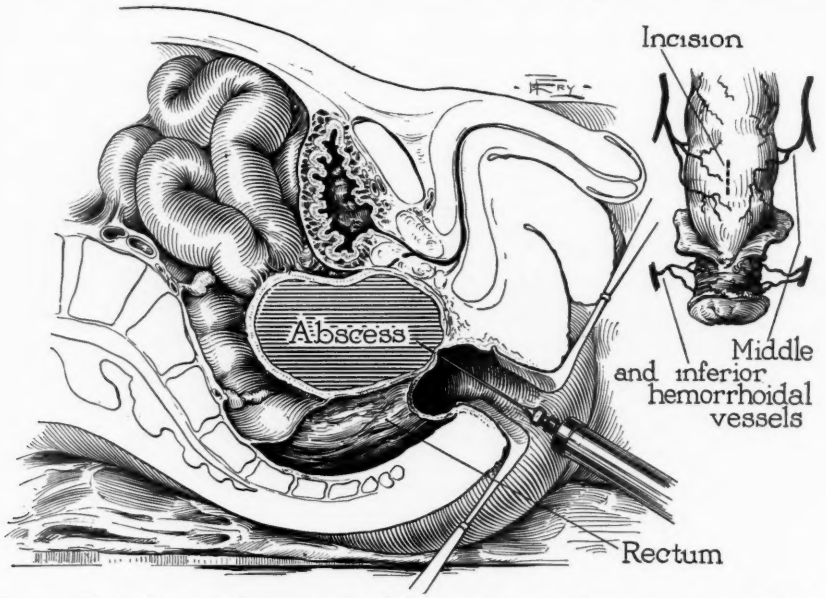

Fig. 4. Technique of drainage of cul-de-sac abscess. After dilatation of the sphincter an aspirating needle is introduced into the softened area of pointing on the anterior wall of the rectum. As shown in the drawing, there is no danger of perforating any loop of bowel, because they are floated above the abscess. After pus has been aspirated a longitudinal incision is made alongside the needle, as shown in the insert. In this way the hemorrhoidal vessels are avoided. The opening is widened by means of dressing forceps and a rubber drainage tube inserted into the abscess cavity.

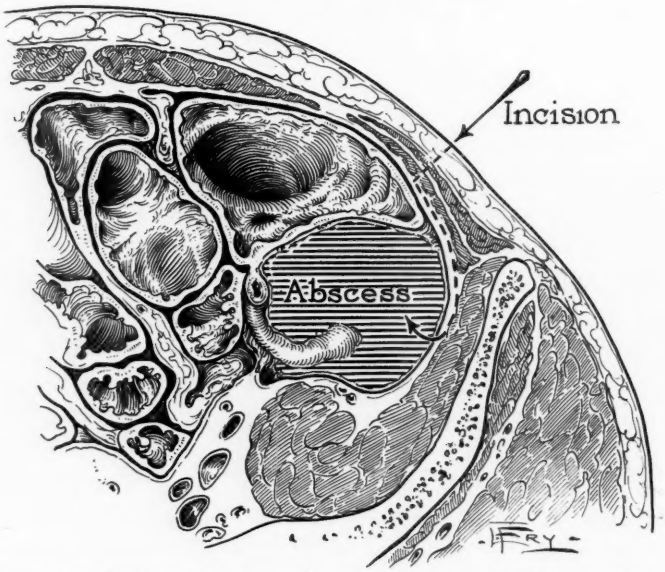

Fig. 5. Technique of extraperitoneal drainage of right ileocecal abscess. Incision is made laterally and the peritoneum peeled away from the abdominal parietes until the abscess is reached. In this way drainage of the abscess is secured without danger of peritoneal contamination.

incision made more laterally in order to drain the abscess extraperitoneally. One should never attempt to remove the appendix in drainage of such an abscess unless it lies perfectly free within the cavity and can be removed without breaking down any adhesions.

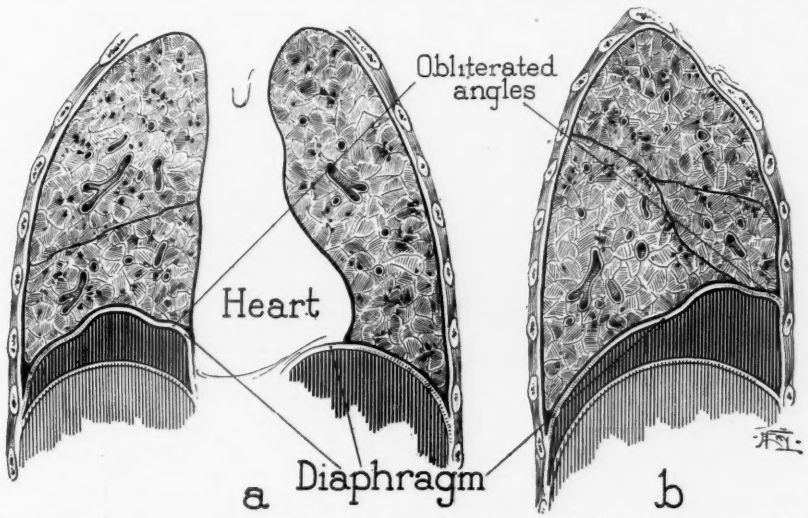

Fig. 6. Diagrammatic drawing showing the characteristic roentgenographic changes in abscesses of the right posterior superior subphrenic space. In the anterior-posterior roentgenogram (*a*) there is elevation of the lateral half of the diaphragm with obliteration of the costophrenic angle. In the lateral roentgenogram (*b*) there is elevation of the posterior portion of the diaphragm with obliteration of the posterior costophrenic angle.

Another complication of appendiceal peritonitis is subphrenic abscess, the importance of which has been insufficiently appreciated. This is largely due to the fact that infections of the subphrenic space as elsewhere in the peritoneal cavity usually subside spontaneously; and, unless one is on the lookout for it, the possibility of its existence is likely to be overlooked and the diagnosis made only in those cases which go on to suppuration. There are certain sites in the subphrenic area in which postappendiceal infections are particularly likely to localize. The anatomy of the subphrenic space has been described in previous reports (Ochsner, Graves, and DeBakey). In 1933, Ochsner and Graves[45] analyzed 3,322 cases of subphrenic abscess collected from the world literature and fifty additional cases treated at Charity Hospital and the Touro Infirmary in New Orleans. Recently, Ochsner and DeBakey[46] analyzed a series of 3,608 cases of subphrenic abscess, most of which followed appendiceal infection. In Ochsner and DeBakey's[46] series there were approximately 15,000 collected cases of acute appendicitis, of which subphrenic abscess occurred as a complication in about 0.9 per cent. These represent only those cases which had progressed to suppuration and did not include the much larger group of subphrenic infections which subsided spontaneously and which were not diagnosed.

The subphrenic spaces which are most likely to become involved in postappendiceal infections are the right posterior superior space, which is a small triangular area located above the liver, to the right of the suspensory ligament and behind the right prolongation of the coronary ligament in immediate contact with the diaphragm. This space is immediately beneath the right twelfth rib. The next most frequently involved space is the right inferior space, which is located below the liver, above the transverse colon and transverse mesocolon, to the right of the ductus venosus, and in the general peritoneal cavity. In a patient who has had an intraperitoneal suppuration, particularly appendicitis, repeated

examinations of the subphrenic area should be made, particularly pressure over the right twelfth rib and pressure along the terior costophrenic angle, and in anterior-posterior roentgenograms (Fig. 6A) an obliteration of the costophrenic angle and

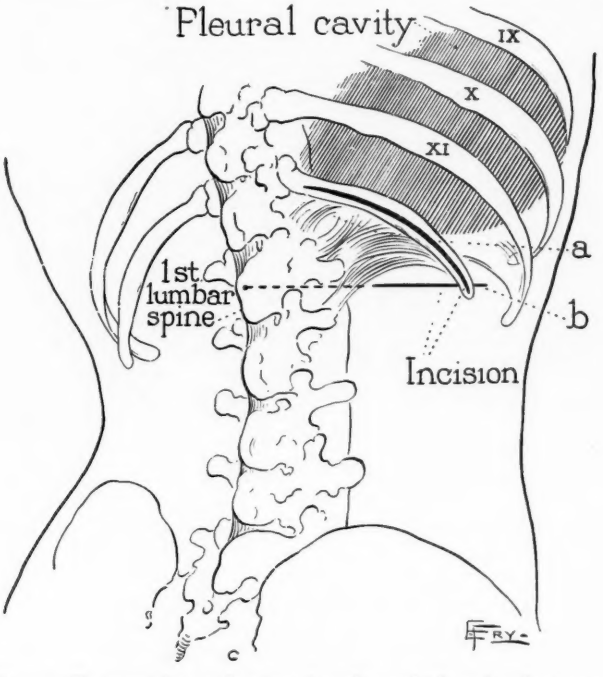

FIG. 7. Retroperitoneal operation for subphrenic abscess. *a*, incision through the skin over and parallelling the twelfth rib. The twelfth rib is resected subperiosteally following which a transverse incision is made through the bed of the twelfth rib at the level of the spinous process of the first lumbar vertebra. In this way there is no danger of injury to the costophrenic reflexion of the pleura. (From Ochsner and Graves, in *Ann. Surg.*, 98: 961, 1933.)

anterior costal margin. A persistence of tenderness over the right twelfth rib on deep pressure, together with the persistence of systemic manifestations of infection in a patient who has or has had a recent appendiceal infection, is suggestive of subphrenic infection with involvement of the right posterior superior space. Similarly, tenderness along the right costal margin is indicative of involvement of the right inferior space. As mentioned above, most of these cases subside spontaneously under conservative therapy. Of diagnostic importance is the immobility and slight elevation of the diaphragm. In the right posterior superior space infections, there is in lateral roentgenograms (Fig. 6B) an elevation of the posterior portion of the diaphragm with obliteration of the pos-elevation of the lateral portion of the diaphragm. Gas under the diaphragm is infrequently found.

If the systemic manifestations of infection in a suspected case of subphrenic infection do not subside, the temperature becomes hectic, and the leucocytosis increases, one is justified in making a diagnosis of suppuration in the subphrenic space, which should be treated by incision and drainage. The drainage should be done in such a way as to prevent contamination of an uninvolved serous cavity. This is particularly important in subphrenic space infections because of the frequently employed transpleural drainage which is likely to result in contamination of the pleura with dire consequences. The importance of this is shown by the collected

statistics of Ochsner and Debakey[46] in which it was found that in 211 cases in which retroperitoneal method of drainage was employed there were forty-four deaths (20.8 per cent), as contrasted with the respective mortality rates of 36.2 per cent and 35.1 per cent, in 394 cases drained transpleurally and in 327 cases drained transperitoneally. Of Ochsner and DeBakey's[46] personal series of seventy-five cases there were thirty-seven drained by the retroperitoneal method with four deaths (10.8 per cent). Still more significant is the fact that in the recent series of cases reported by them[46] there were twenty-five cases, of which fifteen were drained retroperitoneally with only one death (6.6 per cent). The extraserous drainage consists, in the right posterior superior space infections, of employing the retroperitoneal operations previously reported by the authors[47–50] to which the reader is referred. (Figs. 7, 8 and 9.) Through this incision a right inferior space infection can also be drained. If only the right anterior space infection is present, extraperitoneal drainage can be obtained anteriorly by an incision along the costal margin.

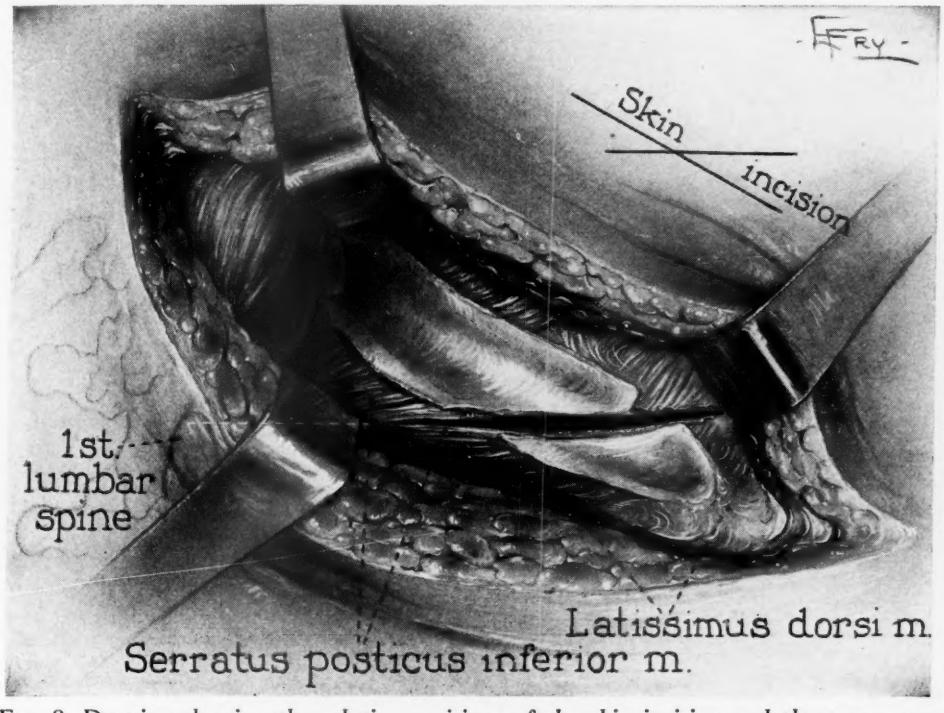

Fig. 8. Drawing showing the relative positions of the skin incision and the transverse incision through the bed of the twelfth rib at the level of the spinous process of the first lumbar vertebra. The latter incision is extended through the attachment of the diaphragm. (From Ochsner and Graves, in *Ann. Surg.*, 98: 961, 1933.)

Relatively infrequently there occurs in children an abscess on the left side which is located usually midway between the left anterior superior iliac spine and the umbilicus or slightly below this level. Its development is due to the fact that because of the shallowness of the cul-de-sac of Douglas in the child the infection rises out of the cul-de-sac and becomes localized on the left side. The clinical manifestations are the same as for a right ileocecal abscess except that the localization is on the left. The treatment consists of ultraconservatism, as most of these cases subside spontaneously and relatively few go on to suppuration. In those cases in which suppuration does occur, incision and drainage in such a way as to prevent contamination of an uninvolved portion of the peritoneal cavity should be done.

The last, and fortunately the least frequently encountered, complication of sup-

purative appendicitis is pylephlebitis or portal thrombophlebitis, a complication which occurs in about 5 per cent of the fatal cases of acute appendicitis and in from 1 to 3 per cent of the clinical cases. The clinical manifestations are those of a severe infection, usually consisting of high fever and recurrent chills. These episodes are due undoubtedly to invasion of the portal system by the inflammatory process and possibly the breaking off of infected emboli which are carried to the liver. The process may be a propagating one with extension of the thrombosis from the appendiceal veins up through the portal radicles and even to the liver. There may occur, as a result of invasion of the liver by infected emboli, multiple liver abscesses.

A patient with acute appendicitis who develops chills should be suspected of having a portal thrombophlebitis and should be operated upon immediately. An attempt should be made to get above the involved segment of vein and to ligate the vein to prevent further propagation of the process. Within the past two years we have observed two cases in which the preoperative diagnosis of pylephlebitis was made and in which at operation a definite thrombosis of the appendiceal veins and its tributaries was found. An attempt was made to get above the thrombosed areas, but this was impossible. The appendix was removed, and subsequently leeches were applied to the patient. Eight leeches were applied daily until the patient's tempera-

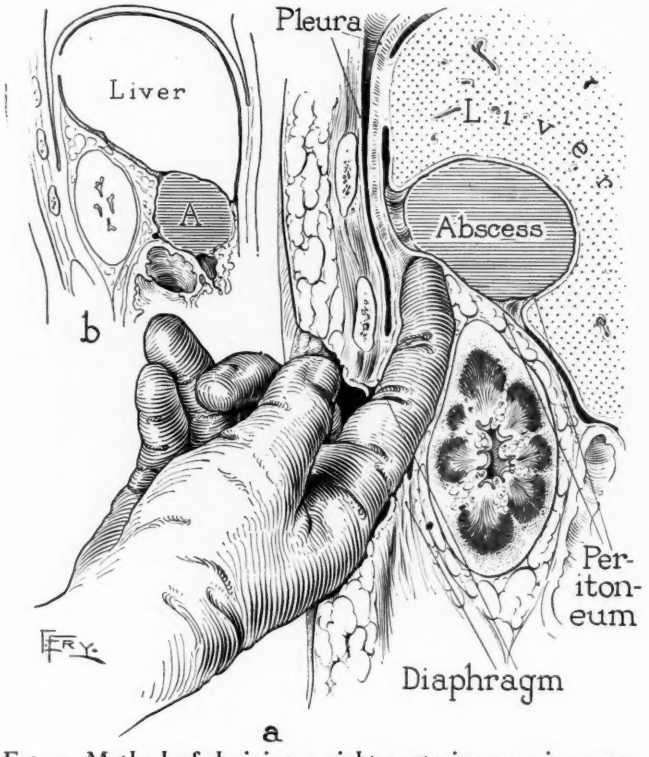

FIG. 9. Method of draining a right posterior superior space infection by means of retroperitoneal operation. The peritoneum is peeled from the under surface of the liver until the abscess is reached. The finger is then plunged through the abscess wall, and the cavity drained. In instances in which there is an abscess in the right inferior space (*b*), the abscess can be drained through the retroperitoneal approach by depressing the kidney downward and draining the abscess extraperitoneally. (From Ochsner and Graves, in *Ann. Surg.*, 98: 961, 1933.)

ture was normal, which in these two instances was on the fourth and fifth days respectively. It is impossible to say just what rôle the leeches played, but it is our firm conviction, based upon the beneficial effects obtained with leeches in thrombophlebitis of the extremities[51] and also because of our experience in other cases of portal thrombophlebitis which were very disappointing, that the leeches were of distinct benefit.

SUMMARY AND CONCLUSIONS

1. Death from appendicitis is largely preventable. Removal of an acutely inflamed appendix while the infection is still confined to the viscus is associated with an almost negligible mortality.

2. Two types of acute appendiceal disease exist, the inflammatory and obstructive. Obstructive appendiceal disease is more dangerous than the inflammatory type because the diagnosis is likely to be delayed and wide spread contamination of the peritoneal cavity follows rupture.

3. The treatment of acute appendicitis is immediate appendectomy, preferably using the inversion, non-ligation of the stump technique.

4. Many cases with peritonitis complicating acute appendicitis are best treated non-operatively.

5. Localization is likely to occur in particular areas of the peritoneum in appendiceal peritonitis. These are (1) cul-de-sac of Douglas; (2) right ileocecal fossa; (3) subphrenic area; and (4) left iliac fossa. Most of these subside spontaneously. If suppuration occurs, incision and drainage in such a way as to prevent contamination of uninvolved serous membranes is necessary.

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ACUTE CHOLECYSTITIS

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DURING the last several years there has been an increasing surgical literature dealing with the management of patients suffering from acute cholecystitis. The general tendency of the communications has been to urge precipitate operation with such a diagnosis. There has been, however, great variance in what is meant by an emergency operation, and indeed as to whether emergency operation is but rarely necessary.

In the surgical service at the Toronto General Hospital, emergency operations for acute cholecystitis are not advocated by the university staff. By emergency operation is meant immediately to carry out the procedure, regardless of the condition of the patient or the duration of the disease. The continued publication of data by men of unquestioned repute, experience and sound surgical judgment, urging that patients suffering from acute cholecystitis be considered as suffering from a disease demanding as immediate operative interference as though they were suffering from acute appendicitis, is so at variance with this practice that a survey of all cases admitted to the hospital, medical and surgical, from July 1, 1926 to January 1, 1934 was made and published (*Canad. M. A. J.*, 32: 283, 1935). The result of this study of our own material was such as to justify the continued conservative management of this group of patients. This material has now been analyzed further from the first of January 1934 to the first of July 1939. In this last survey, we did not concern ourselves with cases which were not admitted to the surgical wards, feeling, as will be shown, that our medical staff coöperated with the surgical staff so completely, that consultation was held on all patients, and surgical therapy was carried out whenever it was advised by the surgical staff. This last group is confined to the patients admitted to the First Surgical Division, together with the private patients operated upon by the author. This entire series presents 273 cases. The total hospital deaths were sixteen in this group, including: (1) patients who refused operation; (2) patients who were not advised to be operated upon; (3) those who were submitted to operation. This gives a gross mortality of 5.8 per cent.

TABLE 1

		Deaths	Per Cent
Total number of cases	273	16	5.8
Total number of cases not operated upon	90	6	6.6
Refused operation	26		
Operation not advised	64		
Total number of cases operated upon	183	10	5.4
Delayed operation	164	7	4.2
Immediate operation	19	3	15.7

In an analysis of the cases in which no operation was carried out, and in which there were six hospital deaths, we find that three were admitted moribund, when no thought of operation could be entertained, and at autopsy all had stones in the common bile duct. Three others died cardiovascular deaths, one from coronary thrombosis, one with accompanying mental confusion and complete lack of ability to coöperate, the result of cerebral arteriosclerosis, and one from auricular fibrillation and circulatory failure. It becomes obvious that in three of these cases even the most enthusiastic advocate of immediate operation would have hesitated because of cardiovascular insufficiency, and had the three who were admitted moribund been subjected to urgent operation, would the

stones in the common bile duct have been overlooked? It does not appeal to us as sound surgical judgment to explore the common bile duct in the presence of acute infection in the gall-bladder. The stone in the common bile duct does not create an emergency in acute cholecystitis, as it must have been present in this site for a long time. Often the emergency could have been controlled with the stones still in situ in both gall-bladder and common duct.

TABLE II

PATIENTS NOT OPERATED UPON

Total number of cases..... 90 Deaths 6—6.6 per cent

26 were advised and refused operation

3 were admitted moribund (at autopsy all had stones in the common bile duct).

3 died cardiovascular deaths, and it was never possible to consider operation.

In an analysis of the cases submitted to operation, one must first of all define what is meant by delayed operation. By delayed operation we mean that the patient is in hospital sufficiently long to have sedatives administered and to restore an adequate balance of body fluids, and salts. This requires from twelve hours to much longer periods. During this time the clinician is given an opportunity to evaluate the progress of the disease, to assess the patient's physique, the history of previous illnesses and their sequelae, and to determine if there are associated disease processes or handicaps from which this patient was suffering prior to the onset of the acute cholecystitis. In other words, the patient who is admitted through the night is not sent to the operating room, but is sent to the ward.

In the group in which an immediate or precipitate operation was carried out, it might be said that in view of the fact that there were only nineteen such patients, our opinion is of little value. This criticism is sound and we are prepared to accept it. Nevertheless an analysis of these patients is interesting.

In this group there were nine errors in diagnosis, the erroneous diagnosis being either acute appendicitis, perforated duodenal ulcer, or acute hemorrhagic pancreatitis. One was a patient mentally ill, in whom immediate operation was urged because of the difficulties presented by the mental state. Another was a doctor who was impressed with the necessity of urgent operation, and demanded that such be carried out. In this group there were thus eleven of nineteen cases in which operation was done for reasons other than a belief that the acute cholecystitis demanded urgent interference in order to save life. One patient was operated upon four and a half hours after the onset of pain, with a temperature of 101 and leucocyte count of 15,000. In this instance there was definite edema about the gall-bladder. Cultures made from the pericholecystic area, from the gall-bladder wall and from the lumen were sterile, both aerobic and anaerobic. In other words, this patient was suffering from an acute cholecystitis of non-bacterial origin, that is, from severe biliary colic. One is apt to lose sight of the fact that a severe biliary colic may be accompanied by fever and increased leucocyte count, and yet no bacterial infection demonstrable. In this group there were three deaths: one due to the progression of an acute pan-

TABLE III

PATIENTS SUBMITTED TO DELAYED OPERATION

Total number..... 164 Deaths 7—4.2 per cent

An analysis of the seven deaths reveals the following:

1 died forty-eight hours postoperatively from anuria and pulmonary edema, the result of a uremic state.

1 was the result of an error in judgment, where the edema which involved the hepatic colon was interpreted as a primary carcinoma of the colon, and a resection done. The patient died of peritonitis.

1 died ten days after operation from an acute pancreatitis, the result of a stone in the ampulla of Vater which had been overlooked at the original operation.

1 died one month after operation from the relentless progress of the associated acute haemorrhagic pancreatitis.

1 died twelve days after operation from a pulmonary embolus.

1 died from shock following a second operation. Following the first operation carried out in the presence of jaundice, this latter persisted, and with the thought that a stone was overlooked in the common duct, a second operation was carried out. No stones found, but shock caused death.

1 died of peritonitis. Had previously had five laparotomies, and adhesions were terrific. It is presumed operative trauma to bowel explains the source of peritonitis.

creatitis; one to the progression of an acute pancreatitis following drainage of the gall-bladder (at autopsy stones were present in the common bile duct); and a third, a diabetic, admitted with general peritonitis, diagnosed as the result of a perforated appendix, at operation found to be due to perforation of the gall-bladder. This last patient died from general infection.

This emphasizes the fact that operative interference may have very little effect on the progression of acute pancreatitis. If one could be absolutely certain of the diagnosis of acute hemorrhagic pancreatitis, it is our impression that the patient would be better if operation were withheld. Furthermore, it again stresses the fact that in urgent operation on these patients, stones in the common bile duct may be overlooked. We all know how difficult it is to avoid this catastrophe in elective biliary surgery, and how much more difficult, to say nothing of how much more hazardous it becomes to the patient if one adds exploration of the common bile duct to an urgent operation which is primarily carried out to prevent death from acute cholecystitis.

Table IV

PATIENTS SUBMITTED TO IMMEDIATE OPERATION

Total number of cases.... 19 Deaths 3—15.7 per cent

Analysis of Deaths

1. Progressive pancreatitis.
2. Progressive pancreatitis. Autopsy showed stone in the common bile duct.
3. Diabetic: perforated gall-bladder; general peritonitis.

It was of interest to separate from this entire group the patients who were operated upon by the staff of the First Division and the author's private patients, following the survey which terminated with the series up to January 1934. This gives us a group from January 1934 to July 1, 1939, of sixty-eight patients, with two deaths, a mortality of 2.5 per cent. Three of the patients refused operation, one of whom has since been operated upon successfully in another city, and two were not advised to be operated on. Their ages were 77 and 88 respectively, and both had associated serious cardiovascular disease. This leaves sixty-three patients upon whom operation was carried out, and there were two deaths —an operative mortality of 2.5 per cent.

Six emergency operations were carried out. In four instances operation was done because of erroneous or doubtful diagnosis. Two cases, previously mentioned, were operated upon immediately on admission, the physician who insisted on immediate operation and the mentally ill patient whose emergency operation was undertaken because of aggravation of mental upset. One death only occurred in the six emergency operations, and this was in a diabetic patient who was admitted with a perforated gall-bladder, erroneously diagnosed as appendicitis, and who died of general peritonitis.

Two most interesting cases are included in this group of six emergency operations. In both the diagnosis was acute appendicitis. In one the abdomen was opened by a McBurney split muscle incision. The appendix was normal. On palpating through the incision one felt a large, tense, distended gall-bladder, which was responsible for the disability. The gridiron incision was closed and the patient was returned to bed. The acute cholecystitis subsided promptly, and three weeks later an elective cholecystectomy was carried out, from which the patient made an uninterrupted convalescence.

The second case was much more illuminating. The abdomen was opened by a paramedian incision, and again the appendix was found to be normal. On this occasion the incision was such that visualization of an acutely inflamed gall-bladder was possible. A greeny black necrotic area was seen in the fundus. This was protected by omentum, and in view of the fact that the patient was elderly, aged 77, had a previous coronary thrombosis, and possessed a seriously damaged cardiovascular mechanism, the abdomen was closed and the patient returned to bed. This patient was seen recently, suffering no disability whatever from his gall-bladder. He has fortunately had no further attacks of acute

cholecystitis, and, because of his serious cardiovascular handicap, elective operation has not been advised. Thus we have definite proof that a gangrenous cholecystitis is not necessarily followed by general peritonitis and is not inevitably fatal.

We were impressed by the group of patients treated conservatively without urgent operation on the gall-bladder. There were fifty-seven delayed operations, with one death—a mortality of 1.75 per cent. This patient died from anuria associated with acute pulmonary edema forty-eight hours postoperatively. It is interesting to note that in this group there were five cases of acute hemorrhagic pancreatitis; in none of them was an emergency operation carried out, and there were no deaths. Six, or 10.5 per cent of the patients had stones removed from the common bile duct when delayed operation was carried out. It being our belief that no exploration of the common bile duct should be carried out in the patients having urgent operation, six of these patients would still harbor serious biliary disease had they been submitted to urgent operation.

TABLE V
SERIES JANUARY 1934 TO JULY 1939

		Deaths	Per Cent
Number of cases	68	2	2.5
No operation	5		
Emergency operation	6	1	16.4
Delayed operation	57	1	1.75
Included			
Acute pancreatitis 5 cases.			
Stone common duct 6 cases			

DISCUSSION

In the selection of the cases which we have analyzed, great care has been taken to make sure that the diagnosis was definitely established. In this group it becomes obvious that the only cases in which there was any question whatever were those in which no operation was carried out. As we are particularly concerned in determining the wisdom of urgent or delayed operative therapy, this group lent a certain weight to the fact that urgent operation is not always necessary. Of the entire group of ninety patients who either refused or were not advised to be operated upon, there were only six deaths, and none of these six patients, we submit, would have been alive had urgent operation been carried out. That some of the remaining eighty-four patients not operated upon may ultimately die from acute cholecystitis is possible. In twenty-six instances, operation was advised and the patients refused. However, we have discharged our obligation to save life, and the patients did not die while under our care. This leaves fifty-eight patients in whom, for various reasons, operation was not advised, and if they succumb subsequently, it will be due to the frailty of human judgment, as their discharge without operation at the time they left our hospital we considered was in their best interests.

That acute cholecystitis should be considered as a parallel disease to acute appendicitis we cannot bring ourselves to believe. In this entire group there were only three cases of general peritonitis, and in the delayed group there were eleven patients who had a perforation of the gall-bladder with a pericholecystic abscess and no general peritonitis, none of whom succumbed to the original perforation nor to the later operation. This tremendous difference between the localization and the diffuseness of the inflammatory reaction as seen in acute cholecystitis and in acute appendicitis we suggest should of itself be sufficient to demand considering these two disease processes as presenting entirely dissimilar problems. We still are struggling in our surgical division with the problem of acute appendicitis. It is rare that the entire staff of the division is not in consultation over the problem which a patient is presenting following the perforation of an acute appendicitis, but it is indeed infrequent to find the staff distressed with the

difficulty of arriving at a decision as to the proper management of a case of acute cholecystitis. We cannot believe that acute cholecystitis in Toronto is any different from acute cholecystitis seen elsewhere. What, then, can explain our apparent placidity in the face of a serious disease? It must resolve itself entirely into a question of terminology. We believe that there are three distinct pathologic entities that in many of the reported publications are called acute cholecystitis, and thus confuse the real issue. We refer to: (1) biliary colic; (2) acute cholecystitis; and (3) acute cholangitis.

The criteria for the diagnosis of acute cholecystitis have in many publications been postulated as disease of the gallbladder, accompanied by severe abdominal pain, an elevation of temperature and pulse rate, and an increased leucocyte count. No case of acute cholecystitis in our experience has ever occurred in which there was not obstruction of the cystic duct, either from stone or thick, tarry bile: hence these criteria may be fulfilled by biliary colic, entirely dissociated from any infection. In the last group of sixty-three operated patients, stones were present in the gallbladder in fifty-six. As a result of this obstructive phenomenon, which we believe to be the basis of the acute cholecystitis, there is an inflammatory reaction characterized by edema, but it is not associated necessarily with infection. That this can occur we have proved by the case of a patient operated upon four and a half hours after admission, with a temperature of 101 and a leucocyte count of 15,000, in which exhaustive bacteriologic study of the material removed failed to reveal the presence of organisms.

Therefore many of the patients operated upon within the first forty-eight hours from the onset of the pain are really *being operated upon for persistent biliary colic.* That this procedure is unwise we do not suggest, but that it is necessary to save life we do not believe. That one can submit to operation within the first forty-eight hours a very large percentage of patients suffering from severe and persistent biliary colic, with a very low operative mortality, is not surprising.

In our series of patients an analysis was made of the length of time between the onset of the symptoms and admission to hospital, and this was found to average six days. Because of the proximity of the colon, which at the end of six days is involved in the inflammatory process initiated by the biliary colic, in which the biophysical properties of both the colon and the gallbladder are altered, infection becomes an additional hazard, which creates a greatly increased risk to life. That this infection may also spread to an involve the common bile duct by the edema with resultant jaundice, presents one of our great diagnostic difficulties. We must determine whether we are dealing with an acute infective cholecystitis, with or without cholangitis, or whether we are dealing with a cholangitis with or without an acute cholecystitis. We have found in an analysis of a former series of patients suffering from jaundice, that jaundice resulted from an acute cholecystitis more frequently than from a calculous obstruction of the common bile duct. In other words, we believe that if we have a palpable, tender mass in the right upper quadrant, accompanied by fever, leucocytosis and jaundice, but no chills, we are justified in assuming that the clinical picture is the result of an acute cholecystitis alone. If to this picture we add recurring chills, then we must assume that there is a superadded cholangitis. This latter complication is, fortunately, rare.

While, as outlined in the data presented, we are content to adopt a conservative attitude in the treatment of acute cholecystitis, we believe that an acute cholangitis is a disease of the greatest seriousness, and that drainage of the biliary apparatus should be established without undue delay. Effective drainage of the biliary apparatus cannot be achieved by a simple cholecystostomy: it must be accompanied by choledochotomy.

This conception of acute cholecystitis is forced upon us by the material with which we are confronted, namely an acute inflammatory process confined to the gall-bladder and accompanied by infection—the infection present because of the length of time that these patients are ill before being admitted to hospital. Such a diagnosis is represented by a patient who has suffered colicky pain of the biliary colic type, has a palpable mass in the right upper quadrant with an associated elevation of temperature and pulse rate, a leucocytosis and occasionally the presence of jaundice. We are quite conscious of our inability always to visualize accurately the degree and extent of the pathologic changes which are present in the gall-bladder. We have presented evidence, however, which suggests this is not so important as some authors would lead us to believe.

While we are willing to accept the criticism that our very limited experience with urgent operation in acute cholecystitis does not permit us to express an opinion that is of the slightest value regarding the merits of this type of therapy, we do feel that we are in a position to state that delayed operation is not so disastrous as it is often painted. The mortality of 5.8 per cent in the total group of 273 cases, in which the histories have been read and accepted for study by the author, we submit, is not forbidding. We have advanced evidence to show that even if a gangrenous patch be present on the gall-bladder, and the gall-bladder is left in situ, the patient does not necessarily die. This is of tremendous importance, because we are very conscious of the fact that the local pathologic lesion as viewed at operation cannot be predicted at all accurately, but if we believe, as there seems to be justification to do, that a gall-bladder which has reached the stage of gangrenous patches can subside so completely that the patient is able to carry on free from symptoms, we are given tremendous moral support and mental comfort in treating these cases conservatively.

The argument that a fair percentage of patients, when they recover from their acute infection, will refuse operation and will thus be in danger of subsequent catastrophe, is not in our opinion valid argument for urgent operation. We cannot force our opinion on an unwilling patient in acute cholecystitis any more than we can in any other disease in which he may choose a course of action at variance with that which we advise. Further, we recognize and accept the criticism that the economic time loss is much greater for the patient treated by the delayed, conservative therapy than for the patient submitted to an emergency operation, providing both patients recover. While this is true, if conservative management carries with it the slightest increased factor of safety, or makes possible a more adequate operation, such as exploration of the common bile duct with, when necessary, removal of stones, then the increased economic time loss should never be a factor in determining our treatment. The evidence presented suggests that delayed operation is safer and more adequate.

While in the experience of the surgeon specialist attached to a large general hospital, the problem of acute cholecystitis is ever present, it is not so with the occasional operator. While one would probably choose otherwise, we must face the fact that the occasional and often the very occasional operator is in our midst, in probably ever increasing numbers. Such operators—many are not surgeons—are probably more justified in their surgical endeavors when dealing with lesions which demand urgent operation in order to save life, than in any other phase of their surgical practice. As they depend to a large extent for their surgical judgment upon the writings and teachings of men attached to large clinics or teaching units, the current literature of recent years would lead them to believe that acute cholecystitis is a disease where urgent operation is demanded to save life. While the expert surgical technician, surrounded by all the facilities and biophysical aids of a large and

well-organized hospital, may successfully operate upon acute cholecystitis with a mortality which is not forbidding, does it seem reasonable that the occasional operator in a small hospital, in the middle of the night, can be placed in the same category? Under such conditions the physician-surgeon is suffering from fatigue, and often only indifferent assistance and anesthesia are available. The biophysical laboratory facilities are lacking, as is often the knowledge which would enable the operator to use them intelligently were they available. Surely the hazard which such a patient accepts is unjustifiable, in view of the data which have been presented here. Under such circumstances the biochemical imbalance should be restored by the administration of water, salt, glucose and blood! Pain and fatigue are overcome by sedatives, and heat applied to the abdomen. This treatment does not need to be persisted in indefinitely, but in our experience the clinical improvement is such that the emergency which was present at 2 o'clock in the morning is often not present twelve hours later. If, however, it should be considered wise to operate at this later time, all resources would be available, and the patient's general condition improved.

What, then, are the criteria which determine abandoning conservative therapy and instituting direct surgical attack? The most important single symptom is pain. If, following the restoration of the biochemical balance and local application of heat, the pain is persisting, despite the administration of what one would consider adequate doses of sedative, operation should be undertaken, even though the temperature, pulse rate and leucocyte count are not increasing. On the other hand, if pain is diminished, the patient is more comfortable, and the general appearance is improving, we need not be stampeded into direct surgical approach simply because the temperature and leucocyte count are increasing. If, on the other hand, there is an increase in the pulse rate, we must pause before continuing conservative plan of management. In other words, the persistence of pain or a persistently maintained high or increasing pulse rate demands direct surgical attack as soon as the patient's biochemical balance is restored by means of the intravenous administration of water, salt and glucose.

When operation has to be undertaken at this time, the degree of edema not only in the gall-bladder wall, but in surrounding structures, with the accompanying increased vascularity, creates a problem in technical surgery which is at variance with those associated with chronic cholecystitis. An incision through the seromuscular coat of the gall-bladder will often permit, because of the edema of the gall-bladder wall, the shelling out of the mucous membrane from the seromuscular coat, very much as one shells a banana from the skin. If, on the other hand, this is not readily possible, the suggestion of partial cholecystectomy advocated by Harry Ritchie and William Estes, Jr.[1] is excellent. In this the gall-bladder is split from the fundus to the cystic duct. The major portion of it is excised, leaving the part attached to the liver intact. The mucous membrane from this area can be removed with a sharp bone curette, and then the remnant is oversewn to control the oozing. Such a procedure avoids, to the greatest possible extent, damage to the liver, and incidentally injury of the common bile duct. By this means one can safeguard the patient to the greatest possible degree. In the districts where operation must be undertaken by the occasional operator, the elapsed time which is necessary to restore biochemical balance permits, to the greatest degree possible, the marshalling of all the resources available, and as a result should work to the advantage of the patients.

CONCLUSIONS

1. An analysis of 273 cases of acute cholecystitis, with a mortality of 5.8 per cent, is presented.

2. Failure to differentiate between biliary colic, acute cholecystitis, and acute

cholangitis, has confused the statistical data presented in the literature.

3. Persistent biliary colic produces an acute cholecystitis, accompanied by increased temperature, pulse rate and leucocytosis, but not necessarily accompanied by infection until several days elapse.

4. Average duration of symptoms in our cases was six days prior to admission to the hospital.

5. Acute cholecystitis with infection presents a history of biliary colic, a palpable, tender mass in the right upper quadrant, increased temperature and pulse rate, leucocytosis and occasional jaundice.

6. Such a case does not demand urgent operation to save life.

7. If after restoring biochemical balance, there is undiminished pain despite adequate sedation, or if pulse rate rises or remains persistently high, direct surgical attack is indicated.

8. In 10.5 per cent of the patients operated on after conservative treatment stone was removed from common bile duct. Exploration of common bile duct is inadvisable coincident with emergency operation.

9. The delay necessary to restore biochemical balance enables the occasional operator to marshall all available resources.

10. While our experience with urgent operation is very limited, evidence is presented of 164 delayed operations with a mortality of 4.2 per cent, leading us to conclude that in such a serious disease, this mortality is not forbidding.

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ACUTE PANCREATITIS*

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ACUTE pancreatitis is a rare disease. At the Henry Ford Hospital, there has been but one operation performed for acute pancreatitis for each 10,000 admissions. It is obvious, therefore, that opportunities for an extensive personal experience with this disease are limited. This fact is reflected in current textbooks in surgery whose authors have been content to follow Moynihan[1] in his dramatic description of the disease and in his advice regarding immediate surgical intervention. It is with these two predominately practical phases of the condition that this presentation will deal.

Brief reference to the salient points of the anatomy, embryology, and physiology of the pancreas is essential because of their bearing on the pathology and treatment of inflammatory affections of the gland.

Embryology. The pancreas, like the liver, develops from the duodenal portion of the foregut. Pancreatic buds grow in both the ventral and dorsal mesenteries. The ventral bud from which develops the head of the organ has a close connection with the hepatic bud which accounts for the common opening of the main pancreatic duct of Wirsung and the bile ducts. The dorsal bud gives origin to the body of the pancreas and the accessory duct of Santorini. Usually the two pancreatic ducts fuse, with obliteration of the terminal position of the duct of Santorini, but occasionally the latter persists and opens into the duodenum about ½ inch caudal to the common opening of the bile duct and duct of Wirsung. Likewise, the common bile duct and duct of Wirsung may open separately into the duodenum.

Anatomy. The pancreas is an entirely retroperitoneal organ, extending transversely across the posterior abdominal wall from the concavity of the duodenum to the hilum of the spleen. The surface marking is the transpyloric plane which is a line drawn at right angles to the long axis of the body at the midpoint between the umbilicus and the xiphi sternum. This corresponds to the upper border of the first lumbar vertebrae posteriorly and also marks the course of the splenic artery which runs along the upper border of the pancreas and provides its main blood supply. The peritoneum of the posterior wall of the lesser peritoneal sac provides a covering for the anterior surfaces of the gland. At the lower border of the pancreas the anterior and posterior layers of the mesocolon separate to provide a peritoneal covering for the transverse colon and in this potential space products of inflammatory diseases may collect to form pseudocysts and abscesses. Also, the lesser peritoneal cavity may be the site of similar formations when the peritoneal covering is destroyed, or injured, for the foramen of Winslow is usually closed by adhesions early in inflammatory diseases or trauma of the pancreas.

Physiology. The pancreas, in addition to its anti-diabetic internal secretion, insulin, pours important juices into the duodenum through the duct of Wirsung. The principal pancreatic ferments are the protein-splitting trypsin, the starch-splitting amylase and the fat-splitting lipase.

ETIOLOGY

The most commonly accepted explanation of the origin of pancreatitis is that bile enters the pancreatic ducts, activates the trypsin of the pancreatic juice, thereby producing autolysis of the gland with re-

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sulting hemorrhage and necrosis. This theory receives support both from occasional autopsy findings of obturation of the bile papillae in fatal cases of acute pancreatitis and from experimental production of the disease in animals by introduction of bile into the pancreatic ducts.

The validity of this theory has been questioned because in only about 10 per cent of patients is it possible to demonstrate anatomically a common channel between the pancreatic and common bile ducts when the bile papilla is occluded by a calculus or by spasm of its sphincter.

Recently Rich and Duff[2] have presented evidence that in some cases metaplasia of the pancreatic ducts results in obstruction, dilatation, and rupture of the gland acini with liberation of trypsin and ultimate autodigestion.

The infective theory long dormant has again received attention following the work of Dragstedt.[3] Spread of infection via the lymphatic system is suggested by the frequency with which chronic pancreatitis is found in conjunction with advanced gallbladder disease, but if this were a common route of infection the association of acute pancreatitis and acute cholecystitis should be more frequent than it is. In a recent, and as yet unpublished series of cases of acute cholecystitis studied at the Henry Ford Hospital, only two were complicated by acute pancreatitis. Blood-borne infection is a possibility clearly indicated by the occasional development of acute pancreatitis in mumps. Furthermore, the clinical picture in fulminating pancreatitis is not unlike that of any other overwhelming infection.

PATHOLOGY

It is generally conceded that changes in the gland are due to autolysis from activation of the proteolytic ferment trypsin. The amount of damage to the gland varies greatly and determines the clinical picture.

A simple classification which recognizes only three stages of a process which may merge imperceptibly from one to another is that of simple edema, acute hemorrhagic pancreatitis, and pancreatic abscesses or pseudo-cysts. Mild degrees of involvement result in simple enlargement and edema of the organ resembling the condition found in chronic pancreatitis except that in the former the gland is much softer. This stage is known clinically as simple edema of the pancreas or acute interstitial pancreatitis and is considered by some observers[4] to be a separate clinical entity, and not merely the beginning of a pathologic process which may go on to complete disruption of the gland.

When the condition is progressive and actual destruction of the gland takes place, we have the stage known as acute hemorrhagic pancreatitis or acute pancreatic necrosis. The involvement can include the whole gland or may be limited to the head, the body, or the tail. The degree of destruction of pancreatic tissue also varies greatly from disruption of isolated lobules to necrosis of practically the whole gland. The amount of hemorrhage depends on the degree of destruction and blood stained fluid collects either in the peritoneal cavity or is disseminated in the retroperitoneal tissues. Liberation of the fat-splitting enzyme, lipase, results in the phenomenon of fat necrosis. These tubercle-like areas in the omentum and mesenteries are diagnostic of the disease and result from the breaking down of fat molecules into fatty acid and glycerine with absorption of the latter and combination of the former with calcium to form the characteristic plaques.

Pseudo-cysts or abscesses are the final stage of the pathologic process. Pseudo-cysts are collections of fluid and products of pancreatic necrosis and collect either in the lesser peritoneal cavity which is usually closed at the foramen of Winslow by adhesions early in the disease, or between the leaves of the transverse mesocolon. Abscesses are either infected localized areas of necrosis or infected pseudo-cysts. This stage is generally found in patients who were treated conservatively either deliberately or because the correct diagnosis was

not made. Recovery is usually prompt after surgical evacuation. The observation that patients who developed this complication usually recovered has formed the basis for the non-operative treatment of acute pancreatitis.

CLINICAL FEATURES

Pancreatitis is a disease of middle age; in our own cases[5] one-third of the patients were between the ages of 40 and 50 and one-half of them between the ages of 40 and 60. Obesity is common. Women are apparently more commonly affected than men, in the proportion of 3 to 2. Fully 60 per cent of patients give a history of previous gastrointestinal disease, and about one-half of them will admit to a previous similar attack of pain though of much less severity.

The classical description of acute pancreatitis is that of a patient complaining of agonizing, upper abdominal pain and presenting signs of pronounced shock and circulatory collapse. However, study of groups of cases shows that the foregoing clinical picture is rarely seen and that the majority of even severe cases presents much milder symptoms.

Pain, the outstanding symptom, is usually severe and persistent. It is located in the mid-epigastrium or just to the right of the midline, thereby resembling acute cholecystitis, but when the tail of the organ is involved, it may be to the left of the midline. Referred pain may be complained of in the back or in the shoulder blades. Rarely the irritating products of pancreatic disruption may trickle out through the foramen of Winslow and pass down the right colonic gutter to give rise to signs simulating acute appendicitis.

Nausea and vomiting are constant symptoms, often initiating the attack and continuing throughout the acute stage of the disease.

Shock. This symptom which receives such prominence in testbook descriptions of the disease is of rare occurrence in our experience at this clinic—an observation that has been confirmed by others, notably Elman.[4] Certainly its absence has no diagnostic significance.

Cyanosis. In contrast to the observations of Halsted and Moynihan, cyanosis is rarely seen except in fulminating cases.

Jaundice. A definite icteric tint is present in about one-fourth of the patients.

Localized Areas of Skin Discoloration. Bluish discoloration of the skin in the flank (Grey-Turner's sign) or around the umbilicus (Cullen's sign[6]) may be observed in from 10 to 15 per cent of patients suffering from acute pancreatitis. This discoloration is due to retroperitoneal dissemination of blood from the disintegrating pancreas. It gives valuable confirmatory evidence, the value of which has been expressed in a previous communication.[6]

Pulse and Blood Pressure Readings. In a series of twenty-six cases of acute pancreatitis proved by operation at the Henry Ford Hospital,[5] the maximum pulse rate was under 100 in 40 per cent of the patients and over 120 in only 125 per cent. The systolic blood pressure was below 100 in only 3.8 per cent of the patients.

Temperature. The temperature is usually moderately elevated. Readings above 102°F. are rare and a normal or subnormal temperature is not uncommon.

Abdominal Distention. There is usually moderate generalized distention due to ileus of the colon. This distention may be pronounced in severe cases and not infrequently is confined to the upper abdomen.

Tenderness. The area of maximum tenderness corresponds in general to the location of the pain and is elicited in the mid-epigastrium in two-thirds of the patients. In some instances it is possible to outline the swollen and indurated pancreas on deep palpation, and after subsidence of acute symptoms, the development of pseudo-cysts and abscesses may be detected readily.

Muscle Spasm. Because of the depth at which the organ lies and its protection by other viscera, muscular rigidity is minimal. It may be entirely absent, but usually both

rectus muscles above the umbilicus are on guard.

LABORATORY INVESTIGATIONS

In contrast to the clinical features which have much in common with other acute abdominal affections, the laboratory investigations in acute pancreatitis are of such significance that positive findings confirm the diagnosis in suspected cases.

Blood Diastase Estimation. The diastase content of both blood and urine is increased in the early acute stage of the disease.[7] It should be emphasized that high readings may be obtained only during the first two or three days of the attack and that normal readings may be found before the attack subsides. Blood diastase estimations are more reliable than urine estimations. Normal readings with the Somogyi test vary from 80 to 150. Using the Meyer's test, readings above 15 are suggestive, and above 20 are definitely indicative of acute pancreatitis.

Leucocytosis. The white blood count is almost invariably elevated and in general the count is higher than that obtained in acute cholecystitis and perforated peptic ulcer—the condition with which acute pancreatitis is most likely to be confused. In our own cases, almost one-half of the patients had a leucocytosis of over 20,000 per cm. mm. The average polymorphonuclear count for the same series was 88.6 per cent.

Blood Sugar Estimation. Contrary to what might be expected, normal blood sugar readings are the rule.

Urinalysis. The toxicity of acute pancreatitis is emphasized by the consistent finding of albuminuria. Evidence of glucose, however, is rare.

Icteric Index. Readings are seldom high, but frequently reveal evidence of subclinical jaundice.

DIAGNOSIS

The diagnosis of acute pancreatitis is frequently missed because the observer fails to consider the disease as a possibility. The typical patient is obese, middle-aged, and suffering from an acute abdominal condition which leads the medical attendant to consider a diagnosis of gallstone colic with or without acute cholecystitis. Further confirmation of this opinion is gained from a history of previous gallstone disease is fully 60 per cent of the patients.

Pancreatitis should be suspected when the pain and vomiting is persistent and more severe than is usual in acute cholecystitis. Tenderness is likely to be in the midline and even to the left when the pancreas is involved. A leucocytosis of over 20,000 per cu. mm. with high polymorphonuclear count should arouse suspicion of pancreatic involvement. Definite diagnostic findings such as a palpable mass in the epigastrium or a positive Cullen's or Grey-Turner's[6] sign of skin discoloration are unfortunately present in only 10 per cent of the patients. A blood diastase estimation made in all patients with the foregoing signs will give a high reading in a surprising number of instances and provide positive diagnostic evidence of acute pancreatitis.

DIFFERENTIAL DIAGNOSIS

Before discussing the differential diagnosis, it is well to emphasize that the present day diagnosis of acute pancreatitis is made by:

1. Consideration of it as a possibility in all acute upper abdominal conditions.
2. Employment of blood diastase estimations in all suspected cases. This test can be run in a few hours and elevations above normal are of definite confirmatory value.
3. Use of the flat abdominal *x*-ray plate to rule out other conditions such as intestinal obstruction, perforated peptic ulcer, etc.,

A few points of distinction between acute pancreatitis and the abdominal emergencies with which it is commonly confused will now be considered.

Acute cholecystitis is a condition which gives the chief difficulty, but in pancreatitis, both pain and vomiting are more severe, the leucocytosis is higher, and tenderness is in the mid-epigastrium or to the left of the midline. It is helpful to remember that, in general, acute cholecystitis tends to subside after seventy-two hours and that if acute symptoms persist after this time, a complication such as empyema, gangrene, perforation, stone in the common duct, or pancreatitis has arisen.

Perforated peptic ulcers, especially pinpoint openings with minimal leakage, may give rise to confusion because of the severity of the pain, but muscular rigidity is pronounced, there is little or no distention and the leucocyte count usually remains below 20,000. Furthermore, a flat *x*-ray plate of the abdomen will usually show free air in the peritoneal cavity.

Acute Intestinal Obstruction. Continuous vomiting and distention often lead to diagnosis of intestinal obstruction, but a flat plate of the abdomen fails to reveal characteristic dilated loop of the small intestine.

Coronary Occlusion. Profound shock and extreme circulatory collapse seen in fulminating cases suggest occlusion of the coronary vessels, but in the latter, the distribution of pain and the absence of local tenderness should lead the observer to consider the advisability of obtaining a diagnostic electrocardiogram.

TREATMENT

The advice of Moynihan[1] regarding immediate operation in acute pancreatitis has been followed for many years. There is, however, an ever increasing number of surgeons[8,9,10,11,12] who not only question the value of early operation, but advise against this practice. It is significant that in most instances the decision to sponsor conservative treatment has arisen from a study of patients treated by immediate operation.

The author identifies himself with the group that advocates expectant treatment. This conclusion was reached after a review of the results of immediate operation in twenty-six patients treated at the Henry Ford Hospital.[5] The finding of a mortality rate of 46.2 per cent in patients so treated was not out of line with reports from other clinics. However, one point in the analysis attracted our attention, and that was the observation that, in 75 per cent of the deaths, the average duration of life was only twenty-one hours. This revelation demanded a revision of our methods of management of acute pancreatitis, resulting in our adoption of the conservative treatment. This change has given us splendid results, for, of sixteen patients so treated, all but one have recovered—a mortality rate of only 6.3 per cent.

The advocates of immediate operation base their contentions upon the theory that the products of pancreatic necrosis are extremely toxic and that their evacuation is essential for the prolongation of life. This theory has been perpetuated because death in the fulminating cases has been attributed to absorption of the end products of pancreatic disruption. Against this theory may be cited the work of Whipple[13] who showed in 1913 that the peritoneal exudate in acute hemorrhagic pancreatitis was innocuous when injected into the veins or peritoneal cavities of animals. Furthermore, cases which have not been diagnosed and go on to abscess or pseudo-cyst formation usually recover after surgical drainage.

The opponents of immediate operation believe that operation not only will not benefit the severe cases but may turn the tide against them, a belief that receives some support from the observation that the duration of life after operation in fatal cases is frequently only a matter of hours.

The greatest drawback to the non-operative method of treatment is difficulty in arriving at the correct diagnosis, for it is obviously dangerous to delay operation if the symptoms are caused by a perforated peptic ulcer or intestinal obstruction. Blood diastase estimations are of such

diagnostic value that few errors will arise if this test is utilized in all cases of doubt. The decision to adopt conservative treatment in any case of pancreatitis should be made only after all reasonable doubts regarding the diagnosis are removed, for if there is any question, operation should not be delayed. Furthermore, just because the expectant treatment is instituted, it does not mean that good surgical judgment should not prevail during the full time that the patient is under observation. For example, a distended gall-bladder should not remain undrained because the surgeon is convinced that a coexisting acute pancreatitis will do better under conservative treatment. Abscesses and pseudo-cysts developing in the region of the pancreas require drainage in accordance with good surgical practice.

If operation is deemed necessary for any reason during the acute stage, it should be performed under local anesthesia because of the imminence of circulatory collapse. Operative procedures should be minimal whether the surgical attack is deliberate, or laparotomy has been performed on the basis of an erroneous diagnosis. The pancreas may be exposed by entering the lesser peritoneal cavity through an avascular area in either the gastrohepatic or the gastrocolic omentum. There is nothing to be gained by incising the peritoneum on the anterior surface of the pancreas because the gland is not possessed of a capsule and thus cannot be decompressed. Furthermore, serious hemorrhage may follow this dangerous practice. All that is necessary, is the placing of Penrose drains in the lesser peritoneal cavity. The biliary tract should be disturbed only if the gall-bladder is distended, and even then cholecystostomy is the operation of choice.

With a decision against operation, adequate supportive measures are indicated. Pain should be relieved by full doses of morphine, and shock should be treated by intravenous saline, and glucose and blood to aid the failing circulation. Continuous suction through a nasal catheter will abolish distressing vomiting. Distention may be alleviated by continuous hot stupes and a rectal tube, with the addition of prostigmin and pitressin in cases unrelieved by simple measures. Food and fluid by mouth are best withheld until the acute stage has passed. Fluid balance is maintained by adequate intravenous and subcutaneous injections of normal saline. A minimum of 3,000 c.c. daily is required and more if there is much loss from the stomach tube. A good practical rule to follow is to administer sufficient fluid to insure a urinary output of at least 1,000 c.c. daily.

Under the foregoing régime, one may expect a subsidence of the acute symptoms in four or five days. The temperature and pulse usually return to normal limits before the leucocyte count comes down. Persistence of the leucocytosis with a return of the fever and temperature elevation should lead the surgeon to suspect abscess or pseudo-cyst formation as evidenced by the development of a mass in the epigastrium.

SUMMARY AND CONCLUSIONS

1. Acute pancreatitis is a rare disease.

2. The most commonly accepted theory of etiology is that based on the activation of trypsin by reflex of bile into the pancreatic ducts.

3. The disease is infrequently diagnosed largely because the observer fails to consider it as a possibility in acute upper abdominal affections.

4. The value of blood diastase estimations as a diagnostic procedure is stressed.

5. Expectant treatment is advocated on the basis of a comparison of methods at the Henry Ford Hospital. A mortality rate of 46.2 per cent occurred in twenty-six patients treated by immediate operation, while in sixteen patients treated conservatively, the mortality was only 6.3 per cent.

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Discrepancies in Hindoo accounts of human anatomy as compared with modern knowledge are probably due not to lack of observation, but to the fact that dissections were made on the bodies of children of less than two years, since older children and adults were cremated.

DIVERTICULITIS

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"LEFT-SIDED appendicitis" is a term frequently used in describing diverticulitis. When diverticula of the distal descending portion of the colon and the sigmoid become the site of an inflammatory process, there occur local tenderness and muscular rigidity; often a mass can be palpated in the lower left abdominal quadrant; the temperature of the body is elevated and leucocytosis usually is present.

Diverticulitis differs from other inflammatory disease of the intestine in that it rarely occurs before the fourth or fifth decade of life. The process is often mistaken for malignancy. During the past decade, surgeons have learned how to differentiate it from neoplastic processes largely on the basis of the patient's history. In those cases in which doubt exists, the service that may be rendered by the roentgenologist is of greatest value.

It is of interest that literally dozens of diverticula may be present in the colon throughout life without producing symptoms or disturbance of function. Only recently, during necropsy at The Mayo Clinic, a colon was removed from the body of a male patient 78 years of age, who had succumbed to coronary disease. Several hundred diverticula were present in the colon in question, extending from the cecum to the upper portion of the rectum. For thirty years prior to this patient's death he had had interval examinations at the clinic, but in no instance did he complain of gastrointestinal disorder.

DEVELOPMENT OF DIVERTICULA

The method of formation of intestinal diverticula, although not known exactly, is thought by the majority of observers to be herniation of the mucosa to a subserous position through the muscular layers of the intestinal wall. Such herniations are thought to occur at sites of least resistance, and so far as can be ascertained, these sites are at or near the openings through which the blood vessels penetrate the wall of the bowel.

Edwards' recent (1936) exhaustive review corroborates the aforementioned view. He points out that the vascular pattern of blood supply to the intestine is constant in that the vessels arise from main trunks in pairs and penetrate the wall of the bowel. As a pair of diverticula enlarge, one diverticulum encroaches upon the other to such extent that the inner wall of each becomes destroyed by pressure; thus, two diverticula are converted into one. Edwards further emphasizes that diverticula almost invariably originate on the mesenteric border, and that an anomalous vessel is usually present at the same site. Although all observers do not fully agree with the idea that acquired diverticula arise from herniation of the mucosa through the wall of the intestine to a subserous position and at the site of vascular entrance into the intestinal wall, nevertheless, the consensus at present is definitely in favor of this view.

The mechanism of formation of diverticula seems logically explained as follows: during the period of contractions, the small vascular openings in the wall of the bowel naturally become smaller, while the opposite is true when relaxation of the intestinal segment takes place. If contraction of two portions of bowel occurs with a relaxed segment between them, a bit of the mucosa may be pushed out through the enlarged vascular opening. In some diverticula, Edwards has shown that the thickening of the muscular coats

may form a collar-band, thus producing a sort of valve.

If diverticula are found in one organ, it is not uncommon to find them in many organs; the condition has been observed in the duodenum, jejunum, colon and urinary bladder of the same patient. It is important to keep this tendency in mind.

SYMPTOMATOLOGY

I am of the opinion that diverticula of the duodenum and jejunum, although they are not uncommon, rarely produce clinical symptoms. Roentgenologists not infrequently report finding a duodenal diverticulum during the process of gastric roentgenoscopic study. Jejunal diverticula are often multiple and occasionally are thought to give rise to a marked "rumbling" soon after the ingestion of food. When diverticula of the small intestine are deemed to require surgical treatment, one of two procedures should be carried out: excision or segmental resection.

By far the most common and most interesting diverticulum of the ileum is the Meckel type. Often this anomaly is found during the course of an abdominal operation that is being carried out for relief of some other condition. It has been my practice to leave such lesions undisturbed if they are an incidental finding and particularly if the diverticulum has a wide neck so that it may empty freely. Meckel's diverticulum has become a clinical entity of greater importance since the discovery was made that occasionally it is the site of mucosal ulceration. The presence of a small amount of gastric mucosa is often found to be responsible for the ulceration; thus, the lesion is indeed similar to a true peptic ulcer.

In the cases of Meckel's diverticulum in which I have performed operation, the outstanding symptoms were intermittent cramp-like pain in the region of the umbilicus and the passage of blood per rectum. A most interesting and instructive case involved a female child 11 years of age, who since birth had passed blood per rectum at frequent intervals. She had the appearance of being undernourished and anemic and was small for her age. A diagnosis of Meckel's diverticulum was made and at operation a diverticulum 66 cm. in length was found in the ileum. In size it was almost equal to the ileum, with which it had a common mesentery. In the distal tip of the diverticulum, an indurated region could be felt; this proved to be an ulcer. Resection would have entailed removal of a segment of ileum equal to the length of the diverticulum itself; since the patient's condition was precarious, anastomosis was made between the intestine and the diverticulum with the idea that more free drainage of the anomaly might bring about healing of the ulcer and sufficient improvement in the patient's condition to warrant resection at a later date. The immediate postoperative convalescence was without incident until the seventh postoperative day, at which time the child contracted pneumonia. She succumbed a few days later. The specimen removed at the time of necropsy showed the ulcer to be the result of the presence of gastric mucosa.

Another important consideration in dealing with Meckel's diverticulum is the possibility that malignancy may develop in the site of gastric mucosa. Such neoplasms have the characteristics of gastric cancer.

DIAGNOSIS

The diagnosis of diverticulum of the Meckel type rarely has been made roentgenologically, a fact that is easily understandable when it is considered that the opening into the diverticulum may be small, thus making the pouch difficult if not impossible to fill with opaque media. Only on two occasions has Weber been able to visualize the presence of Meckel's diverticulum. Both of the patients concerned had symptoms which prompted the clinician to emphasize the need of careful search for such a lesion during roentgenologic study of the small intestine.

Diverticula of the colon warrant more discussion than do lesions of similar character in other segments of the intestine, because (1) they are far more common, and (2) more frequently they become the site of inflammatory disease, than do other intestinal anomalies. Occasionally, both a malignant process and diverticulitis are found in the same segment of the intestine, but this finding is rare. Diverticula, so far as is known, are not the precursors of cancer.

The presence of diverticula in the right half of the colon is comparatively rare, and rarer still is diverticulitis in the proximal portion of the large intestine. Diverticulitis and diverticulosis are found more commonly in the descending colon and the sigmoid than elsewhere.

When diverticulitis occurs in a portion of the left half of the colon, the signs and symptoms of an acute inflammatory process are present. The diagnosis of diverticulitis of a portion of the left side of the colon or sigmoid is no longer the difficult problem it was two or three decades ago. Signs of inflammatory disease of acute or subacute nature in the left abdominal quadrant of persons of middle age at present suggest the possibility of diverticulitis. The patient's clinical history is of great importance, because a differential diagnosis between malignancy and diverticulitis is the problem to be solved. Bleeding from the bowel is an extremely rare accompaniment of diverticulitis, whereas it is an outstanding symptom of carcinoma of the colon. Constipation of increasing severity may be present in both conditions, but that type which is associated with diverticulitis is often more acute than other types. Finally, the signs of an acute infectious process favor a diagnosis of diverticulitis unless there is a history of long standing suggesting the presence of a malignant process which may have perforated. When roentgenologic studies of the colon of a patient who has diverticulitis are made, the characteristic observation is usually the presence of uninvolved diverticula proximal and distal to the filling defect. The latter have a serrated pattern, whereas if carcinoma is present, the characteristic defect is more clear-cut and the proximal and distal limits of the disease have, in the roentgenogram, a concave or crescent-like appearance and, as a rule, no diverticula are present.

TREATMENT

The care of patients with diverticula in the proximal portions of the intestinal tract has been discussed. Diverticulitis is of more frequent occurrence in the more distal segments of the alimentary canal. The treatment of diverticulitis is first of all a medical problem. Once the diagnosis is made, the patient should be hospitalized, and should ingest a liquid or nonresidue diet. Warm, massive stupes should be applied to the abdomen. Rectal irrigations, using warm saline solution, are often of great benefit. The use of belladonna is frequently of aid in relaxing, at least partially, the spasm that is present at or near the site of the disease. If, after eight to twelve days, definite improvement is not in evidence, such as abatement of the signs of inflammation and release of the obstruction, surgical interference would seem to be in order. In such cases, my practice has been to perform colostomy in a proximal, nondiseased segment of the colon. By deflecting the fecal current through the stoma thus formed, the disease may show marked regress within a few weeks. In cases in which colostomy is deemed advisable, it is usually a judicious plan not to attempt closure of the artificial stoma for at least twelve months, even though roentgenographically the site of the obstruction may show marked improvement. In some instances the patients have insisted that closure of the colonic stoma be carried out within a few weeks after its establishment. In many of such cases it has been my experience that a flare-up of the process will occur, requiring reëstablishment of the colonic stoma.

If, after the previously described program has been given a fair trial, it is found that the diseased segment of bowel remains obstructed or nearly so, segmental resection is in order. Such a procedure may be carried out with end-to-end anastomosis, or an extraperitoneal operation may be performed. The latter procedure will require closure of two artificial colonic stomas, but for debilitated patients this often seems the safer plan.

Perforation of colonic diverticula with formation of abscess is best managed by allowing sufficient time to elapse for complete localization to the site, after which drainage of the surrounding abscess is usually necessary. This complication sometimes is responsible for the formation of a small colonic fistula which may close spontaneously. If, after four to six months, healing has not occurred, it has been my practice to perform colostomy in an uninvolved segment of intestine well above, or proximal to, the fistula. Here again, deflection of the fecal current frequently allows the fistula to close spontaneously. But should the fistula persist, one of two operative procedures are in order: closure of the fistula, or segmental resection, depending on the extent of the diverticulitis.

Perforation of a colonic diverticulum into the urinary bladder, according to my experience, almost invariably necessitates resection of the diseased colonic segment and closure of the opening in the bladder. In cases of this nature, I have found it prudent to carry out the procedure in stages, the first being colostomy, usually in the transverse colon, which is followed in six to eight weeks by resection of the affected portion of the bowel. Marked induration of a considerable portion of the wall of the bladder is present in association with the majority of enterovesical fistulas, and the presence of the induration necessitates wide excision. A suprapubic cystic stoma should be established and allowed to function for from three to five weeks, after which withdrawal of the catheter will bring about rapid healing of the urinary sinus.

It is well to emphasize again that a diverticulum of the colon may be associated with carcinoma, but that it is not a precursor of a malignant process and, therefore, a trial of conservative treatment is justifiable; if satisfactory results do not follow this method of attention, a more radical procedure is indicated, which is to say, resection is advisable.

THE DIAGNOSIS AND TREATMENT OF SMALL BOWEL OBSTRUCTION*

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INTRODUCTION

UNTIL a few years ago, it was generally admitted that there had been very little progress in reducing the mortality of acute intestinal obstruction. Besides the paraoral administration of fluid and electrolytes, the treatment consisted chiefly of enterostomy with or without release or removal of the obstructing mechanism. The average mortality from these surgical procedures was 40 to 100 per cent depending upon the duration and nature of the obstructing lesion, the condition of the patient, and the surgical procedure performed (Shelley, Vidgoff, Cornell, Koslin, Colp, van Beuren and Smith, Wangensteen, Christopher and Jennings).

It seems that in past years enterostomy was used in the treatment of acute mechanical and paralytic ileus of the small bowel because no other more effective treatment was known. Within the last ten to fifteen years, however, medical measures have replaced the surgical treatment of acute dilatation of the stomach and paralytic ileus of the small bowel. The medical treatment has consisted of gastric lavage, spinal anesthesia, pituitary extract, morphine, intravenous saline and glucose, rectal tubes, etc. (Shelley). Of these gastric lavage with or without siphonage or constant suction has proved most effective (Janeke, Woolsey, Ramona and Rey, Ward, Bartlett, Wangensteen).

In 1931, Wangensteen was the first to suggest and use constant suction applied to an indwelling duodenal catheter in the treatment of acute mechanical ileus. Since then his ideas regarding the therapeutic problem in intestinal obstruction have been generally accepted. The purpose of this paper is to discuss the use of siphonage drainage in certain cases of ileus and to review the present methods of diagnosis and treatment of acute obstructions of the small bowel as carried out at the University of Minnesota Hospitals.

DIAGNOSIS OF ACUTE INTESTINAL OBSTRUCTION

The whole problem of ileus resolves itself into a differentiation between (1) simple and strangulating obstructions and (2) acute obstruction of large and small bowel. By simple ileus is meant one on a mechanical or neurogenic (spastic or paralytic) basis. By strangulating obstruction is meant one in which the blood supply, either arterial or venous, to the gut has been compromised.

1. *Acute Obstruction of the Small Bowel.* The first step in the treatment of acute obstruction of the small bowel is a carefully taken and carefully evaluated history. The patient complains of intermittent, crampy, colicky pain; nausea and vomiting. On physical examination, the abdomen is found to be distended. The presence of abdominal scars and hernia should be noted. Peristalsis may be visible through the abdominal wall. The presence or absence of rebound tenderness should be ascertained by palpating the abdomen. On auscultation of the abdomen with the stethoscope, the presence of borborygmi should be determined as well as whether the intestinal noises are most intense at the height of abdominal pain.

Determination of the values for the blood chlorides, urea nitrogen and carbon dioxide combining power of the blood gives confirmatory evidence of small bowel obstruction, in that a hypochloremia,

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alkalosis and elevated urea nitrogen are usually present, especially if the obstruction is high in the intestinal tract. The most valuable of the laboratory aids is the *x*-ray film of the abdomen. It should be emphasized, however, that the *x*-ray pictures unless viewed in the light of the clinical and physical findings may be more misleading than helpful. All that the roentgenograms will show is (*a*) whether there is an obstruction present; (*b*) whether it is complete or partial; and (*c*) whether the large or small bowel is involved. Also they will help to determine the position of the indwelling duodenal tube and any increase or decrease in the amount of intestinal distention. They will not tell whether the obstruction is paralytic, mechanical or strangulating in nature, which is of paramount importance in the rational treatment of ileus. One must differentiate these various forms of obstruction by means of the clinical findings. One distinguishes mechanical from paralytic obstruction by the absence of intestinal noises in the latter condition upon auscultating the abdomen. In strangulation obstructions, the abdomen is more tender, rebound tenderness as well as intestinal colic may be present. Shock supervenes sooner in strangulating than in mechanical ileus.

2. *Colonic Obstruction.* Distinction must be made between obstructions of the large and small bowel. In cases of colonic obstruction, the patient complains of gas pains, cramps, diarrhea or constipation, blood in stools, weight loss. Vomiting is *not* a prominent feature until late in the disease. On physical examination one finds varying degrees of abdominal distention depending upon the duration and acuteness of the obstruction. A scout film of the abdomen will show a distended colon with little if any distention of the small bowel. This is thought to be due to the competency of the ileocecal sphincter, but how often this sphincter is competent in colonic obstruction is not known. A barium enema may reveal the obstructing lesion, but too much importance should not be attached to a negative report. If one inserts a gastric tube, one obtains only clear juice from the stomach. This is an important differential sign, for in small bowel ileus one obtains "feculent regurgitation" upon aspirating the stomach. Also in contradistinction to cases of small bowel obstruction, study of the blood chemistry in colonic obstruction is of little value.

TREATMENT OF ACUTE OBSTRUCTION OF THE SMALL BOWEL

Conservative Therapy. Paralytic ileus and partial mechanical ileus on an adhesive basis are ideally treated by siphonage drainage. Strangulating obstruction and acute complete obstruction of the large bowel are *never* treated conservatively but should be operated upon as early as possible. Conservative treatment of paralytic and mechanical ileus of the small bowel consists of constant suction applied to an indwelling intestinal catheter (Wangensteen or Miller-Abbott tubes), hot packs to the abdomen, fluids, and sedatives. The purpose of the hot packs is merely to make the patient more comfortable. Paraoral fluids, chiefly intravenous saline, replace water and electrolytes lost by vomitus, the urine, transudation of fluid into the lumen of the distended bowel, etc. Sedatives are usually not needed if the suction is working well and if just a simple obstruction is present. Narcotics should never be used for fear of masking signs of peritoneal irritation such as occur in strangulating obstructions. At this clinic, sodium luminal is given hypodermically for relief of restlessness and discomfort incident to confinement in bed. Fine has suggested the inhalation of 95 per cent oxygen to relieve the gaseous distention in intestinal obstruction. This is a valuable adjunct but the best results are obtained when its use is combined with siphonage drainage of the bowel (Wangensteen, Boothby).

Erroneous Ideas Regarding the Conservative Treatment of Acute Simple Ileus of the Small Bowel. Conservative treatment does not imply that suction siphonage is all-

sufficient and that the general condition of the patient may be disregarded. If the patient with intestinal obstruction is to be treated conservatively, constant vigilance must be given his condition. Flat plates of the abdomen (scout films) must be made every twelve to twenty-four hours, and the clinical status of the patient checked at frequent intervals. In using siphonage drainage, it is important that (a) the tube be in or beyond the duodenum; (b) the suction be working; (c) the fluid intake and output be carefully computed; (d) the plasma proteins and blood chlorides be checked frequently. At this clinic patients who have been treated by indwelling duodenal catheter with constant or intermittent suction for more than a week, are given a blood transfusion even if the plasma proteins are within normal limits.

It is foolhardy to use siphonage drainage as a diagnostic test of intestinal obstruction; that is, siphonage drainage should not be used in cases of ileus with the idea that if the patient does not improve he probably does not have a simple ileus and should be operated upon. An attempt to diagnose correctly the type of ileus should always be made before instituting therapy. The practice of employing suction as a test procedure to indicate whether operation will be necessary leads only to deferment of appropriate treatment (Wangensteen).

Operative Treatment of Small Bowel Obstruction. If one suspects a strangulation obstruction or in cases of simple ileus if suction is unsuccessful in effecting decompression, an operation is in order. At operation if the patient is markedly distended, and if a strangulating obstruction is not present, only an enterostomy should be performed. The importance of an aseptic technique in the performance of enterostomy has been stressed by Wangensteen. Spillage during the performance of an enterostomy in acute intestinal obstruction invariably means death from peritonitis. If a strangulating obstruction is found, freeing of the obstructing mechanism, resection, or exteriorization of the affected bowel should be performed.

Criteria for the Relief of Intestinal Obstruction and After-Care. The criteria for the relief of intestinal obstruction in the conservatively, as well as in the surgically treated cases are the clinical and physical improvement of the patient and the absence of gas in the small bowel of adults by *x*-ray.

After removal of the siphonage tube the patient should be given a bland or low residue diet with mineral oil. Four to six weeks later a gastrointestinal study with barium sulfate by mouth (stasis ray) is performed to rule out any intrinsic obstructing lesion. The insertion of a Miller-Abbott tube down to the suspected site of the obstruction followed by the administration of barium through the tube will often aid in diagnosing an intrinsic obstructing mechanism. Occasionally a pneumoperitoneum is carried out to note the degree and position of intraperitoneal adhesions. In certain cases of intestinal obstruction secondary to pelvic inflammatory disease, Elliott treatment to the pelvic organs or other form of fever therapy is given, with or without a subsequent enterolysis.

Patients who present themselves with the abdomen scarred from many previous operations and have symptoms of acute mechanical intestinal obstruction, may be suffering from anorexia nervosa, or chronic morphinism. In our experience these patients are best treated by siphonage drainage. Enterolysis gives very unsatisfactory results in these cases.

Theoretical Objections to Conservative Treatment of Intestinal Obstruction. There are several theoretical objections that have been voiced against the conservative treatment of mechanical ileus:

1. In conservatively treated cases of mechanical ileus, one can only rationalize as to the obstructing mechanism, while if one operates upon all these cases, one can actually determine the nature of the obstructing lesion. Granting that this be

true, knowledge of the exact nature of the obstructing lesion is of little therapeutic value if the patient is markedly distended. In such cases it is more important to relieve the distention than to remove the blocking mechanism. Experience has shown clearly that obstructed patients with marked distention stand very little surgical interference. The statistics of Cheever and Körte show that the mortality of resection, enteroanastomosis, freeing of bands, etc., is three times greater if the bowel is distended than in the same operation done when the bowel is collapsed.

If the patient is very distended, it may be with difficulty that one finds the obstructing mechanism. Moreover, if the intestine is acutely dilated, exploration of the abdomen with the resultant trauma of the serosal coat of the bowel is dangerous. A serous peritoneal exudate is often changed to a purulent peritonitis by bacteria migrating through the bowel wall injured as a result of manipulation. Rather than explore cases of mechanical ileus with marked distention in which the site of obstruction is not evident, it is safer to perform a "blind enterostomy."

There is some danger that atypical cases of intussusception, obstructions due to impacted gallstones in the bowel, and strangulated internal hernia may be confused with simple obstruction and treated conservatively. In the case of intussusception, the age of the patient, the palpation of an abdominal mass, the presence of blood in the stool will be of diagnostic aid. One may not find rebound tenderness in cases of intussusception even though the intussusceptum be gangrenous if it is well ensheathed by the intussuscipiens. Similarly in strangulated internal hernia, if the hernia be well ensheathed by the hernial sac, rebound tenderness may be absent. The association of ideal obstruction due to gallstones with a cholecystenteric fistula, resulting in gas being visualized in the biliary tree by roentgenograms, may be of value. The surgeon should always remember that if the patient with a supposedly simple ileus does not improve with conservative therapy, some complication may be present and he should not temporize too long with the conservative régime. At this clinic by following this rule, we have yet to fail to recognize and institute proper therapy in cases of intussusception and intestinal obstruction due to gallstones.

2. Can one drain the bowel better by enterostomy or siphonage drainage? Theoretically suction applied through a tube inserted through the nose and passed into the duodenum accomplishes the same purpose as a catheter inserted into the bowel by enterostomy. Moreover siphonage drainage carries no operative risk. True, the most effective drainage is that obtained just above the obstruction; duodenal suction may be considered a non-operative form of "blind enterostomy." One is impressed by the fact that the amount of gas and fluid that escapes through an enterostomy tube is never so great as that obtained by suction from an inlying duodenal catheter in cases of ileus. However, the quantity and continuance of escape of gas and fluid in cases of intestinal obstruction are correlated more with the degree of obstruction rather than with the site at which the enterostomy is made.

3. If a patient with intestinal obstruction due to adhesions is treated conservatively and recovers, the obstructing mechanism is still present and may later be a potential source of danger. One must remember, however, that the patient probably had the adhesions for a long time before the ileus, but what caused them suddenly to become an obstructing mechanism is unknown. Since adhesive formation is part of the normal process of repair, if one operates upon such a patient, one has no assurance that the patient may not become obstructed subsequently by newly formed adhesions. Most surgeons would agree that a single obstructing adhesive band should be cut or removed. Just when to do this has been the subject of controversy. Our experience has been that if the patient is markedly distended, division

of the obstructing band is best deferred to a subsequent operation after the distention is relieved.

4. It is difficult to get a suction catheter into the duodenum? It takes but little practice to become proficient in passing a suction catheter through the nose into the duodenum. If the patient will not coöperate, if the obstruction has been of long duration, or if the distention is so marked that the duodenum or stomach is compressed or displaced, it may be difficult or impossible to get the tube into the duodenum. A special catheter with a leaded tip (Wangensteen tube) or the Miller-Abbott tube is used. To be certain of the location of the tube, an *x*-ray film of the abdomen must be made. Aspiration of bile does not prove that the tube is in the duodenum as aspiration through a tube coiled up in the stomach may reveal bile that has been regurgitated from the duodenum into the stomach. In an uncomplicated case, according to our technique, it takes about forty-five minutes from the time the Wangensteen tube is inserted through the nostril until its position in the duodenum is verified by *x*-ray.

5. Is siphonage drainage to be considered a substitute for surgery in intestinal obstruction? As mentioned before, strangulating obstruction and acute complete obstructions of the large bowel are never to be treated conservatively but should be operated upon as quickly as the condition of the patient permits. Siphonage drainage may be used only as an ancillary measure in these cases.

However in cases of simple ileus, as paralytic ileus and mechanical obstructions on an adhesive basis, siphonage drainage is not only a substitute for surgery but is to be preferred from the point of view of surgical mortality and end results. Colp, in 1936, in a review of the use of enterostomy at Mt. Sinai Hospital, New York City, conclusively proved that it had no place whatever in paralytic ileus. Van Beuren and Smith in a review of the literature found that the mortality of operation in cases of acute ileus was about twice as great when an enterostomy was performed as when it was not. In 1937, these same authors reviewed the average mortality over a twenty-year period in cases of acute ileus operated upon at the Presbyterian Hospital, New York City. The mortality had been reduced from 66.6 per cent (1916 to 1919 inclusive) to 28.4 per cent (1932 to 1935 inclusive). They believed the reduction in mortality to be due to (1) earlier diagnosis and operation; (2) a clearer concept of the problem to be solved by treatment; and (3) more intelligent handling and management of the cases. This improvement applied to the cases upon which an enterostomy was effected as well as to those upon which it was not done but the reduction in mortality was much greater in the latter group. This discrepancy appeared to be due in part to the fact that the group in which an enterostomy was not performed was operated upon earlier.

In 1929, Miller published a study of 171 cases of intestinal obstruction from the New Orleans Charity Hospital covering the period 1923 through 1927. The mortality was 70.7 per cent. In 1934 Moss and McFetridge published from the same institution a series of 340 cases covering the period from 1930 to 1934. The mortality was 31.7 per cent, less than half of the series reported by Miller. In 1937, Boyce and McFetridge continued these studies, adding 204 cases covering the period from 1933 through 1935. The mortality was 36.3 per cent. This increase in mortality over Moss and McFetridge's series they believe to be due to the use of conservative therapy on ill-advised indications and in improper cases of intestinal obstruction.

Johnson, Penberthy, Noer and Kenning, in a series of fifty-four patients treated by intubation of the small intestine, reported a mortality of 25.6 per cent (fourteen patients). Of these, five, or 9.3 per cent, died as a result of intestinal obstruction. In the remaining nine who died, intestinal intubation was carried out to relieve disten-

tion associated with other conditions which caused death.

The experience of this clinic with all types of mechanical obstruction of the small bowel over a seven-year period between June 1, 1931 and June 1, 1938 has been reviewed by Wangensteen, Rea, Smith, and Schwyzer. Among 156 patients treated for acute mechanical obstruction of the small intestine, there were, because of repetition of obstruction in some patients, 190 cases. There were twenty-eight deaths in the entire group, a patient mortality of 17.9 per cent and a case mortality of 14.7 per cent.

Of the cases in which suction was the primary treatment although in some of these an operation became necessary to affect a satisfactory decompression, there were ninety-six patients and 126 cases of obstruction. There were fifteen deaths, a patient mortality of 15.6 per cent and a case mortality of 11.9 per cent. In those instances in which suction *alone* accomplished a satisfactory decompression and relief of the acute obstruction there were sixty-four patients and eighty-three cases. Five deaths occurred, giving a patient mortality of 7.8 per cent and a case mortality of 6 per cent.

At this clinic 61.5 per cent of patients and 66.3 per cent of cases of all patients with acute mechanical obstruction of the small bowel were treated by siphonage drainage. Suction alone was used for relief of the acute obstruction in 41 per cent of patients and 43.6 per cent of cases.

Of the patients with acute ileal obstruction treated by immediate operation, there were fifteen intussusceptions. The mortality of operation (usually reduction) in these cases was 40 per cent. The poor condition of most of these patients on admission to the hospital undoubtedly affected this mortality. Reduction by barium enema was attempted in ten cases; in eight of these the intussusception was partially reduced. In one of these the reduction was found to be complete at operation.

The mortality at this clinic in cases of strangulated inguinal, femoral, and incisional hernia (twenty-eight patients and twenty-nine cases) is 32.1 per cent of patients and 31 per cent of cases. However, in cases of strangulated incisional hernia, the mortality is 58.3 per cent (seven of twelve cases). It is our policy to operate upon these cases at once, no matter how grave the situation may appear. For strangulated incisional hernia division of the constricting bands without repair of the hernia would appear to be the procedure of choice. The prophylactic repair of all unobstructed incisional hernias is probably the best way to lower this mortality. From the work of Wangensteen and Scott the factor of blood loss into the gut is important in the lethal outcome of strangulation obstruction. At this clinic blood transfusions are given to all patients with strangulating obstruction even though there be no signs of shock. The importance of this procedure can not be overemphasized.

SUMMARY

1. The problem of acute intestinal obstruction of the small bowel resolves itself into a differentiation between (a) simple and strangulating types of obstruction and (b) acute obstructions of the large and small bowel.

2. In any case of ileus an integration of the history, physical findings, laboratory data, especially *x*-ray films, must be made.

3. Suction applied to an indwelling duodenal tube has a definite rôle in the treatment of acute intestinal obstruction. In acute mechanical and paralytic ileus complete relief of the obstruction may be obtained through this agent *alone*. In fact the lowest mortality yet reported for mechanical obstruction (6 per cent) has been with conservative therapy. Strangulating obstructions and acute complete obstructions of the colon should be treated by immediate operation. Siphonage drainage may be used as part of the treatment in these latter types of obstruction but its importance is secondary to operative treat-

ment of the obstructed gut. If the indications and limitations of suction in the management of obstruction are kept in mind, there can be no doubt that a definite lowering of the mortality of acute intestinal obstruction is obtained by this method.

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OBSTRUCTION OF THE LARGE BOWEL

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OBSTRUCTION of the large bowel, because of its insidious onset and subtle progress, is a vicious and dangerous clinical entity. It becomes manifest in one of three forms, depending upon the degree of encroachment upon the lumen of the bowel, and the element of time involved in the progressive obliteration of visceral continuity. Clinically, this combination of circumstances evolves itself into either the acute, subacute, or chronic form of obstruction and if the time factor is prolonged, the individual case may progress through a series of all three of these stages in reverse order. The predominant cause of physiologic derangement in simple obstruction of the colon is distention, with subsequent damage to the bowel wall following progressive vascular occlusion from excessive intracolonic pressure.

Obstruction of the colon may or may not be associated with other pathologic changes in or about the bowel wall which profoundly alter the clinical picture, its course, treatment, and progress. These complicating factors therefore suggest the grouping of large bowel obstruction into: first, the simple mechanical obstruction as seen for example in bands, kinks and some of the congenital anomalies; second, obstruction superimposed upon malignant disease of the colon, diverticulitis, veneral strictures, etc.; and finally, the group in which obstruction is associated with a strangulating process such as volvulus, intussusception, or incarceration.

In the first group, simple mechanical obstruction is unassociated with other complicating processes which influence the general physical condition of the patient as well as the surgical approach. The second group includes those patients ravaged by coincident disease and suffering at times profound physiologic depletion, which in itself is a serious problem to be dealt with in addition to the condition at hand. In the group which includes strangulation with obstruction, the picture is one of acute surgical shock and here again the entire course of the disease, its progress, and treatment are widely at variance with that of the first two types of occlusion.

The clinical picture resulting from large bowel obstruction differs greatly from that seen in obstruction of the small intestine because it is in effect a closed loop system. In addition to the inability to evacuate by regurgitation, the secretions of the upper alimentary tract are continuously being poured into the colon to supplement the existing accumulation of fluid and gas. This portion of fluid, arising from glandular secretions, according to Rowntree, reaches a total of approximately 7000 c.c. during twenty-four hours. About 1500 c.c. of saliva are swallowed daily, the stomach produces between 2000 and 3000 c.c. of gastric juice, while the biliary system elaborates some 500 to 800 c.c. of bile. Pancreatic secretions total between 300 and 500 c.c., while the succus entericus amounts to about 3000 c.c. In experimental obstruction of the colon in dogs, Wangensteen found that the accumulation of gas in the large bowel rather consistently about doubled that of the fluid content, and analysis revealed the following component gases in approximately these proportions: carbon dioxide, 6.5 per cent; oxygen, 1.2 per cent; nitrogen, 80 per cent; methane, 2.6 per cent; hydrogen sulfide, 6.7 per cent; and traces of hydrogen. In an analysis of the gases from a human colon obstructed by cancer of the rectum, the proportions very nearly approach these findings. There are three sources of gaseous

accumulation in the obstructed gut: the formation of gas from digestive processes; the diffusion of blood gases into the lumen of the bowel; and the atmospheric air swallowed. The latter, however, plays a small part in large bowel distention in contrast to obstructed small intestine.

A substantial portion of this rather surprising quantity of materials passes the ileocecal orifice through which it cannot be regurgitated because of the check valve action of the sphincteric mechanism. Although roentgenologists frequently report the passage of barium into the lower ileum, it must be remembered that the excessive weight of the barium, the rapidity and increased pressure with which it is introduced, along with the touch of the lead-gloved hand produce far from what may be considered optimum physiologic conditions. They overcome the force of the delicate muscle fibers of the ileocecal sphincter, while the slowly progressive effect of gradually increasing distention incident to obstruction serves to render it more impervious to back flow.

In the closed loop system of large bowel obstruction there is therefore an entirely different effect from that in obstruction of the small intestine. Vomiting is not a common occurrence early in the disease and is evidence of a long standing process. In consequence, electrolytic depletion and excessive dehydration with resulting alterations in blood chemistry are not factors of emergency importance. This is best evidenced by the relative uselessness of parenteral salt solution as contrasted with the dramatic results from its use in high intestinal obstruction. Likewise, the use of continuous duodenal suction is of small value in relieving existing colonic distention, although it may help to minimize the additional burden of a continuous flow of gas and secretions from the upper alimentary tract.

In obstruction of the large bowel unassociated with strangulation the principal causes of death are all dependent upon and directly traceable to the one outstanding characteristic of the closed loop system—distention. The old theories of toxemia from the mysterious, highly-popularized, histamine-like substances have largely fallen into the discard. Distention is the "bête noire" of colonic obstruction and by means of this phenomenon alone the culminating tragedy of its subtle progress is inevitable.

With increasing intracolonic pressure the gut wall is stretched until paper thin, the muscle fibers lose tone to become exhausted, there is peristaltic inertia and ileus, with stagnation. The blood supply is soon comprised with first, venous occlusion, resulting in chronic passive congestion which, as the arterial flow continues, produces a condition analogous to strangulation with its shocking effect from excessive blood loss. The bowel wall then becomes edematous, small hemorrhagic areas appear, necrosis ensues, and perforation may result.

Tension on the bowel wall is directly proportional to the diameter of the lumen of the gut, and as Wangensteen has demonstrated, the tension per square centimeter in the cecum is over twice that of the descending colon. As previously mentioned, the effect of strangulating obstruction of the large bowel is primarily that of extensive blood loss into the injured segment, while massive tissue destruction with bacterial invasion due to abnormal permeability of non-viable gut, distention and ultimate perforation follow in rapid sequence. It is of interest to note that in spite of positive cultures from intraperitoneal lymph glands for a variety of different organisms, as reported by many observers, successful recovery following adequate surgical intervention is the rule.

Considerable work has been done to observe the alteration of bowel absorption in the obstructed gut. Absorption takes place through the portal system, the lymphatic system, and by means of permeability through the transperitoneal route. In the distended bowel there is a retardation of venous absorption but apparently

there is no definite proof of the absorption of toxic substances thought to be elaborated in the injured viscus. The lymphatic absorption of dye materials and bacteria is increased with a progressive rise of enteric pressure while permeability is proportional to tissue damage of the bowel incident to circulatory interference.

With enormous distention incident to obstruction of the lower colon or rectum, there is progressive cardiorespiratory embarrassment which adds to the individual's distress, but even more harmful and considerably less noticeable is the effect of venous congestion of the lower extremities. This phenomenon causes a relative decrease in blood volume with an excessive accumulation of metabolites, so that it adds to the shocking effect of simple obstruction in a manner somewhat similar to that of strangulation, although, of course, it is far more subtle and much less severe. There is likewise a decrease in plasma protein and blood volume incident to the accumulation of intracolonic fluid as well as intraperitoneal exudate which results from injury to the distended bowel wall. In animal experimentation with intestinal obstruction, the average loss of plasma volume has been found to be 36.4 per cent in four to six hours, or 2.8 per cent of body weight, 3.4 per cent of body weight being considered a lethal plasma loss. The mechanism by which distention causes plasma loss seems best explained by venous obstruction with a continuous arterial inflow resulting in gut wall edema and the intraperitoneal and intracolonic accumulation of the transudate.

Considerable work has been done on the determination of blood potassium in shock from hemorrhage and from trauma, in intestinal fistula and obstruction, and it has been found that there is a correlation between the prelethal state of these conditions and the blood potassium. Just what the similarity is which produces this physiologic alteration, is not altogether clear. Whether cause or effect, it remains to be determined, but there is definite evidence of clinical importance in the work which is being carried on by Whipple, Scudder, Zwemer, and others.

ETIOLOGY

The causes of colonic obstruction are many and varied and in order best to illustrate the types of disease which produce the condition, Table 1 is presented as a simple, practical, and approximately complete classification.

TABLE 1

OBSTRUCTION OF THE COLON

Mechanical Obstruction

1. Adhesive bands
2. Volvulus
3. Intussusception
4. Hernia
5. Foreign bodies

Congenital Obstruction

1. Imperforate anus
2. Atresia of the rectum
3. Anomalous termination of the colon
4. Bands and constrictions
5. Megacolon

Neurologic Obstruction

1. Adynamic ileus
2. Spastic ileus
3. Hirschsprung's disease
4. Chronic obstipation

Extrinsic Lesions Causing Obstruction

1. Adjacent malignant disease
2. Pelvic tumors
3. Mesenteric cysts and tumors
4. Adjacent inflammatory disease
5. Retroperitoneal tumors

Intrinsic Lesions Causing Obstruction

Inflammatory Disease

1. Diverticulitis
2. Appendicitis
3. Epiploitis
4. Lymphogranuloma veneria
5. Syphilitic strictures
6. Gonorrheal strictures
7. Nonspecific

Post-ulcerative Strictures

1. Tuberculosis
2. Actinomycosis
3. Ulcerative colitis
4. Amebic or bacillary dysentery
5. Chemical ulceration
6. *X*-ray and radium

Post-traumatic

1. Direct trauma
2. Detachment of mesentery
3. Small mesenteric thrombosis
4. Post-incarcerational stricture
5. Injury from over-distention

Malignant Disease

1. Adenocarcinoma
2. Epidermal carcinoma
3. Sarcoma

Mechanical Obstruction. Mechanical obstruction of the colon in the simplest form is rare and is usually caused by postoperative or congenital bands which gradually contract upon the entrapped bowel first to retard and finally to occlude the passage of intestinal content. Angulation

from postoperative adhesions may produce a similar sequence of events while foreign bodies must also be included in this group. Extracolonic pressure alone from retroperitoneal or intramesenteric cysts or tumors have all been reported as causative agents, as have pelvic tumors, although the latter are rare, for the colon may, through its mobility and pliability, so readily adjust itself to such conditions that it rarely becomes pinned between fixed structures. Recently we operated upon a patient with a large lipoma of the mesentery of the sigmoid which had begun to encroach on the lumen of the gut.

Herniae of all varieties have been noted as causes of obstruction by incarceration or strangulation. Inguinal, femoral, umbilical and incisional herniae have all taken their toll. Diaphragmatic herniae, internal herniae of various sorts and congenital openings of the mesentery have likewise been observed.

Congenital Obstruction. Congenital obstructive abnormalities of the colon are not exceedingly rare and when present are frequently associated with anomalies elsewhere. They range all the way from the imperforate anus to entire atresia of the colon. The continuity of the large bowel may culminate in a small fistulous tract which opens into the bladder, the urethra, the vagina, or the vulvovaginal orifice. The anus or rectum may be entirely absent, or with the fully developed anus and failure of descent of the rectum, a simple membranous diaphragm may be present, whereas the two blind pouches may be joined by a fibrous cord. Narrowing of the anal canal may occur, which produces a partial obstruction. This may be present in the form of a stricture-like process, or involve a segment of the bowel. It is at first in no sense of the word a stricture, but with subsequent trauma it may through constant irritation develop into a true cicatricial process. The etiology of Hirschsprung's disease is far from clear, as evidenced by the total of a huge list of theories advanced by many authors, but it is generally believed that certain types of megacolon are definitely related to developmental abnormalities whether they be obstructive, neurogenic, or structural defects such as redundance of the rectosigmoid or elongation of its mesentery.

Volvulus. Volvulus of the colon is a result of tortion on a long mesentery and most commonly occurs in the sigmoid, although the cecum, both flexures, or the redundant transverse colon may become involved. When the process reaches 180 degrees rotation, obstruction is supplemented with the effect of strangulation for beyond this point vascular injury is inevitable. Volvulus may occur in one of three ways: first, by circular rotation about a fixed point; second, by an elliptical rotation about two fixed points; and third, by rotation about the longitudinal axis of the viscus. Presupposing the necessary anatomic factors, the catastrophe may be precipitated by various exciting causes such as violent peristalsis following heavy purgation, overeating, tumors, mesenteric cysts, fecaliths, foreign bodies or direct violence. Pregnancy has been mentioned as a causative agent, but it is probably a coincidental finding in most cases.

Intussusception. Intussusception is an interesting form of obstruction of the colon which most commonly occurs in infancy and childhood and is often associated with vascular damage dependent upon the extent and duration of the process. Multiple intussusceptions are said to occur in 10 per cent of the cases, although Clubbe in a series of 253 cases reported it to be present in 31.8 per cent, while Crohn noted it eleven times in fifteen cases. Intussusception may be of four types: first, involving only the small intestine; second, involving the small intestine which has prolapsed through the ileocecal valve; third, intussusception of the ileocecal valve itself into the colon; and finally, when only the colon is involved in the process.

A combination of circumstances, producing hypermotility plus the anatomic considerations observed in infancy and

early childhood are believed essential to the majority of such cases. The frequency with which ileocecal and cecal involvement occurs, lends credence to the hypothesis of Perrin and Lindsey who feel that hypotrophic lymphoid structures about the ileocecal valve and terminal ileum act somewhat as do polyps or foreign bodies which in the face of abnormal peristalsis tend to become prolapsed into the distal gut.

Functional Obstructive Disorders of the Colon. In discussing this group of conditions which lead to varying degrees of colonic obstruction, the multiplicity of theories as to the etiology of chronic obstipation, intestinal stasis, megacolon, and the like, presented in the vast literature on the subject are productive of a discouraging paucity of fact. Suffice it to say that bad habits, inertia, chronic nervous exhaustion, as well as hypo- or hyperneurogenic activity, vitamin deficiencies, and similar vagaries seem to play an important rôle in some of the more exaggerated forms of chronic obstipation. However, it has been repeatedly observed that in the aged, the sick, the indolent, decrepit, and insane, fecal impaction is a prevalent cause of obstruction. Hirschsprung's disease though discussed under congenital disorders of the colon, must in some instances fall into this group of disorders.

Inhibitory Ileus. Inhibitory ileus, often spoken of as adynamic obstruction, can be as difficult and dangerous as any form of intestinal obstruction. The motor balance between the sympathetics and parasympathetics has been disturbed by an excessive sympathetic stimulation which completely inhibits all motor activity. It may develop from intra- or extra-abdominal trauma, surgical or otherwise, infections such as peritonitis, pneumonia, and other septic conditions, while extra-abdominal conditions such as fractured ribs, renal calculus, torsion of the testicle, etc., may be responsible. Usually the entire intestine is involved. Occasionally, however, only portions of the small or large bowel may be affected.

Spastic Ileus. Spastic ileus is usually segmental. The gut is intensely contracted and obstruction is complete. Hyperirritability may result from injury, foreign bodies, worms, or irritating intestinal content, etc. The spastic segment may be in the form of a ring-like constriction or involve a large segment of gut. It may occur in the colon or small intestine and for a time persist in causing an obstruction which is difficult to differentiate from simple mechanical obstruction.

Inflammatory Processes. Heading the list of inflammatory processes which cause obstruction of the colon, is diverticulitis. Acute appendicitis, and acute epiploitis have also been recorded, while the group of processes which fall into the classification of granulatomatous diseases of the large bowel contribute an appreciable percentage of obstructing lesions. Commonest of these is lymphopathia veneria. Tuberculosis (hyperplastic in the cecum), and actinomycosis rarely produce obstructing lesions of the colon, while syphilis and gonorrhea are considered as equally rare causes of ano-rectal strictures. Lymphogranuloma veneria has in the past decade been given considerable study, and it is probably the true cause of the many lesions which in the older literature were classified as non-specific, gonorrheal, or syphilitic.

Ulcerative processes in the mucosa of the large bowel caused by ulcerative colitis, dysentery, chemical ulceration, or contusions may produce cicatricial stenosis of the colon, while a localized injury to the blood supply such as a small infarction, thrombosis, or tearing of the mesentery, may produce a similar lesion. *X*-ray or radium used in the treatment of cervical, fundus, or bladder cancer have caused extensive inflammatory strictures of the rectum or rectosigmoid. We have operated upon two such cases in the past six months.

The commonest among the obstructing lesions of the colon is cancer. In discussing malignant disease of the large bowel, it should be remarked that rarely has sarcoma of the colon arising from the submucosal

structures been recorded as encroaching upon the visceral lumen. Epidermoidal carcinoma usually appears at the mucocutaneous juncture of the anus, but occasionally is found to arise from the mucosa elsewhere in the colon. Endometriosis, although not considered a malignant disease, may likewise invade the colon. The authors have observed and treated two such cases during the past year.

Due to the frequency with which carcinoma of the colon causes obstruction, either partial or complete, the surgical significance of this type of lesion is self-evident. The growth is nearly always in the left colon, rectum, or left half of the transverse colon, although it may occur well up toward the hepatic flexure. Occasionally a carcinoma of the cecum will, by dint of its unusual size and proximity to the ileocecal valve, produce obstruction of the terminal ileum. This, however, is rare and under such circumstances the picture is one of small bowel obstruction.

Cancer of the colon may appear in the form of an ulcerative, penetrating lesion characterized by a paucity of glandular tissue which is thinly scattered throughout a fibrous superstructure, giving the effect of scirrhous carcinoma. Grossly, there is a raised, irregular, granular ring encircling the ulcer which has a flat necrotic center. As the ulcers gradually increase in size, more and more of the bowel wall becomes involved and cicatrization gradually causes a stricture-like closure of the lumen. Again, a small nodular mass with minimal ulceration may cause an occluding stricture or a large annular growth may completely encircle the lumen of the bowel. Still other carcinomata may be the polypoid protruding types, which project well into the lumen of the bowel. Microscopically, these tumors are composed mostly of the glandular element with minimal fibrous tissue framework. All variations between these two extremes may be found, as well as the gelatinous carcinoma which is a highly differentiated glandular tumor, the acinous cells of which are mucus-secreting. Obstruction is less often observed in the latter because the protruding types of growth usually cause them to be discovered before obstruction has developed. Due to the larger diameter of the right colon and the fluid character of its content, obstruction rarely occurs in the right half of the bowel, but it is far more common with lesions beyond the mid-portion of the colon than is generally suspected. Burgess, in a study of 485 cases of cancer of the colon, observed the incidence of obstruction to be 35 per cent. Statistics in this country from large urban hospitals are higher.

As the process progresses the lumen may be decreased to a centimeter or less in diameter before complete obstruction occurs, but during this time the bowel wall proximal to the growth has become thickened and hypertrophied, and the mucosa engorged and edematous with areas of ulceration caused by the impaction of inspissated fecal matter. The final step in the occlusion is usually the inflammatory reaction and edema incident to irritation and infection, although it may be caused by the accumulation of fecal matter above the lesion. Too often even now the catastrophe is precipitated by the oral administration of barium at the hand of the over-enthusiastic roentgenologist. This has repeatedly resulted in death and cannot be too emphatically condemned.

SIGNS AND SYMPTOMS

Colonic obstruction is usually a slowly progressive process ushered in by episodes of mild colicky pains and abdominal distention. There may be alternating periods of diarrhea and constipation or the latter may progress to obstipation in spite of repeated medication. On the other hand, the first evidence of colonic disease may be complete occlusion of the bowel. This type of onset is most commonly observed in elderly patients found in the large charity clinics and city hospitals. Not infrequently these patients can point to the exact site of obstruction, which is usually a result of carcinoma. When not associated

with incarceration or strangulation, even complete obstruction of the large bowel may be a subtle and insidious process. Slowly progressive abdominal discomfort gradually develops into intermittent cramping pains which increase in frequency and severity as distention becomes more and more pronounced. This distention never produces prominence of the lower mid-abdomen with stepladder pattern and visible peristalsis as seen in obstruction of the small intestine. Protruding of the flanks and upper abdomen are typically present in obstruction caused by lesions low in the colon and as meteorism increases and abdominal discomfort progresses, patients complain of indigestion, lassitude and weakness. They become restless, apprehensive and drawn in appearance. The skin is dry, the pulse quickens, and while the picture is one of impending disaster, these patients rarely vomit, although they may at times complain of nausea.

The symptomatology of obstruction from cancer of the colon is dependent upon two factors: the difference in physiologic function of the right and left half of the large bowel and the pathologic variation observed in carcinoma in the different segments of the colon. Because of the great diameter of the cecum and ascending colon, the fluidity of its content, and the noncicatrizing proliferative type of growth, it may be easily understood why obstruction is not a predominant feature in cancer of the right colon. Lesions in this half of the bowel are either discovered accidentally as a palpable mass in the right lower quadrant, or present one of two symptom complexes: the vague dyspeptic picture, or the severe anemia. The former are usually diagnosed as chronic appendicitis, chronic cholecystitis, or intestinal indigestion, while the latter are often confused with pernicious anemia. Carcinoma of the left colon is manifest by irritability of the colon with change in bowel habit, intermittent spells of diarrhea or constipation, blood in or on the stool, and all other manifestations of an obstructive process. Pain, cachexia, and weight loss are late manifestations of malignant disease and suggest metastasis.

In striking contrast to this insidious course, the sequence of events following obstruction of the colon associated with incarceration, strangulation, or intussusception, moves with a terrifying rapidity often associated with agonizing pain and early prostration. Distention is quick to appear and often extreme in its intensity. The pain is generalized, often variable in persistence and in severity, but always associated with tenderness as evidence of peritoneal irritation. A palpable mass may or may not be present but with intussusception, the classical tumor is usually found and the diagnosis is relatively certain.

DIAGNOSIS

Frequently, the diagnosis of intestinal obstruction, acute or subacute, is made with little difficulty, but this is by no means a constant observation. Usually a history of episodes of cramping colicky pain, progressive abdominal distention, obstipation, nausea and vomiting are the predominant features which combine to portray the clinical picture of intestinal obstruction. Having concluded that there is an obstruction to the continuity of the gastrointestinal tract, the site of this lesion is a matter of great importance. The differentiation between large and small intestinal obstruction is evidenced clinically by the rapid progressive depletion incident to intractable vomiting, the step-ladder pattern, and visible peristalsis characteristic of small intestinal obstruction, in contrast to the slow development of meteorism with flank distention and milder, more generalized, colicky pain. Often one or more stools may pass following the onset of small gut obstruction, but this is rarely seen in colonic obstruction.

Localization of the process is of importance because of its bearing on treatment. Perhaps the most helpful procedure recently developed for the diagnosis and location of an intestinal obstruction is an

x-ray of the abdomen. Here the intestinal patterns are visualized and with skilful interpretation, the site and type of lesion may often be determined accurately. Naturally, the ingestion of barium is not a part of the procedure, but a flat plate only is taken.

TREATMENT

Therapeutic measures to be instituted in the face of colonic obstruction are dependent entirely on the nature and duration of the obstructing lesion. The variation in treatment may range from enemata through the simple nick of a congenital membrane occluding the imperforate anus, all the way to resection of a large segment of strangulated bowel caught in the twist of a volvulus.

Usually the congenital obstructions are best treated by early surgical intervention, for if the process is evident shortly after delivery the infant is then at its best and delay will only serve to deplete its reserve and increase the detrimental effects of the obstruction.

In colonic obstruction of adults, not infrequently, what appears to be a complete obstruction of the colon can be relieved by the adroit use of enemata, thereby eliminating the need for emergency surgical decompression. In obstructing carcinoma of the left colon and rectum, an appreciable percentage may be added to this group—if patience and care are used in giving repeated irrigations with large quantities of fluid.

Physiologic changes incident to the presence of chronic depleting disease, or acute septic processes must be combated by means of parenteral fluids, blood transfusions and vitamin concentrates. The recent advances in chemotherapy have been beneficial in the management of septic complications occurring in diverticulitis and there is slight evidence to suggest the value of sulfanilamide in the treatment of lymphopathia veneria.

During the preoperative preparation of completely obstructed patients suffering from progressive distention, the use of 100 per cent oxygen has, in our hands, been found quite effective. The procedure is simple, requiring only the mask pressure gauge and oxygen tank and in the course of four or five hours, while other supportive measures are being carried out, distention is appreciably reduced, the comfort and general condition of the patient are improved and the surgical endeavor is greatly facilitated.

In the strangulating obstructive processes, the element of primary importance to be combated is the shock incident to decrease in blood volume. Blood loss into strangulated tissues is no more nor less than active hemorrhage and must therefore be treated as promptly and vigorously as intra-abdominal bleeding from a ruptured viscus. It must be emphasized here that in strangulating injuries of the bowel, if the vascular occlusion can be relieved before mesenteric thrombosis has occurred, deflation of the affected segment by means of a fine needle and hot salt packs to the bowel for as long as five minutes by the clock, will often revive what appeared to be a hopelessly devitalized segment of gut. Careful inspection and palpation of the mesentery is, however, essential before one is justified in abandoning resection. One or two adroitly placed sutures should prevent the recurrence of a volvulus or intussusception if one is so fortunate as to discover he has explored in time to find viable gut.

If, on the other hand, a large segment of bowel has become gangrenous, the procedure of choice is an obstructive resection and complementary cecostomy. Rarely can a primary anastomosis be performed, but even here, the complementary cecostomy, a matter of only several minutes, will greatly improve the prognosis. Primary anastomosis is to be condemned for the following reasons: (1) because it is a time-consuming operation and it is difficult to be sure of safe blood supply to the bowel ends; (2) end-to-end anastomosis is, moreover, not only dangerous, but impractical

because of the difference in the diameter of the lumen of the gut above and below the obstruction; (3) the suturing of edematous gut in the side-to-side anastomosis is unsurgical and requires excessive time; and (4) the majority of strangulating obstructive lesions of the colon occur on the left side where the fecal content is no longer fluid, an additional factor to jeopardize the anastomosis which even in the properly prepared colon, heals none too kindly.

Exteriorization of a large loop of gangrenous gut, often pictured in the older textbooks and all too frequently done even now, should be assiduously decried. The procedure is often actually harmful. In the first place, it does not relieve obstruction; secondly, it is a continuous source of tissue fluid loss through osmosis and diffusion; thirdly, it is for the same reason a constant source of toxic absorption and bacterial invasion; and finally, if the arterial supply is not divided and ligated, small quantities of blood continue to flow through the lesser arteries and arterioles which pass into the viable extremities of the exteriorized loop, while the smaller veins at the borderline area, far more easily compromised than the arteries, fail to return it to the systemic circulation. Furthermore, if time can be taken to ligate the blood supply only a few more minutes are required to apply a clamp and convert the entire affair into a precise, surgical procedure which not only greatly facilitates adequate closure of the abdominal wound, but eliminates the imminent possibility of subsequent peritonitis, wound infection, or evisceration.

The rationale of therapeutic attack in obstruction of the colon is dependent upon procedures calculated to protect the viability of the bowel wall against overdistention and vascular damage; in short, decompression and relief of strangulation. The latter is always an emergency measure and usually the process demands immediate eradication. If, however, the obstructive agent does not jeopardize the blood supply, as in the case of neoplastic or chronic inflammatory disease, decompression is the single aim of surgical invasion.

In the acutely ill patient, the obstructive process having been localized to the colon, the procedure of choice often is blind cecostomy through a split muscle incision in the right groin, performed under local anesthesia. When possible, it is advisable to exteriorize the cecum or a portion of the ascending colon in order completely to by-pass the fecal current and to permit of subsequent irrigation which cleanses and rehabilitates the bowel, preparatory to surgical extirpation of the obstructing lesion. Although the cecum may often be delivered with ease, this is not always the case. Great difficulty may be encountered when the cecum is firmly fixed to the parietes, and again when it is hugely distended and its wall paper-thin, the danger of perforation from the gentlest manipulation is imminent. Under such circumstances, it is best to pack carefully around a portion of the anterior wall of the cecum, and by means of a small needle, withdraw the gas. The relaxed wall rapidly becomes thickened by engorgement of the mucosa, and edema of the submucosal and serosal coat, so that it may be more easily handled with less danger of perforation and soiling. Having accomplished this, there remains the choice of suturing a tube, preferably a large one, into the bowel, suturing the bowel to the peritoneum, or fashioning a loop cecostomy.

Recently, in our service, cecostomy for the relief of acute intestinal obstruction has been performed sixteen times. In eight of the cases, subsequent resection was impossible, and in the remaining eight, obstructive resection completed the procedure. Table II shows the conditions which caused the obstruction.

Table II

CECOSTOMY FOR ACUTE INTESTINAL OBSTRUCTION

Cancer of transverse colon	3	Postoperative adhesions, large and small bowel	1
Cancer of sigmoid	5	*X*-ray stricture of descending colon	1
Cancer of rectum	2	Cancer of left colon	1
Cancer of rectosigmoid	1	Cause unknown	2

The danger of abdominal exploration in the face of acute obstruction should be emphasized, for it does, without question, greatly increase the risk of complicating sequelae. Likewise, the danger of sudden collapse following rapid, complete decompression of the hugely distended colon is analogous to that following immediate relief of urinary obstruction and must be borne in mind. The mechanism of this catastrophe is not altogether clear, but it seems entirely probable that the sudden flow of blood into an atonic vascular bed produces a puddling or stagnation of blood and tissue fluids in the engorged wall, which creates in effect a decrease in blood volume analogous to hemorrhage. Care must therefore be taken to avoid precipitous evacuation of distending media.

Once the patient has recovered from the effects of decompression, local and general measures of rehabilitation are begun in order to prepare for subsequent surgical removal of the obstructing lesion. If, up to this point, a definite diagnosis has not been reached, the search may now be carried on without danger to the patient. Proctoscopic examination may be used to explore the rectum and recotsigmoid for lesions beyond the reach of the examining finger. If the site of the obstruction has not been revealed by a flat plate of the abdomen as previously suggested, a barium enema is then indicated.

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ACUTE PERFORATIONS OF "PEPTIC" ULCERS

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IN order that this discussion be confined within the limits of the space allocated to it, I will not discuss the intermittent perforations which progress by a series of acute attacks; each of which penetrates deeper and deeper into, or through, a resisting wall. Some of these communicate with localized and well walled off abscesses, and a few establish fistulae with some other portion of the intestinal tract, such as the justly dreaded gastro-entero-colic type. Nor will I discuss perforations usually found on the posterior wall and associated with massive hemorrhage, for these constitute a somewhat different problem.

As a general rule, it is easy to make the correct diagnosis of an acute perforation of a gastric or duodenal ulcer from the clinical picture, and to do so without the aid of the *x*-ray. In the vast majority of cases, the *x*-ray is of confirmatory assistance only, but, it should be used in every case where it is possible to do so. In only one case have I seen it to be of distinct harm, and, there the damage was due not to the *x*-rays, but to the delay engendered in convincing the radiologist that a patient could have an acute perforation of the gastrointestinal tract without the *x*-ray plate showing the air space between the liver and the diaphragm when the picture was made with the patient in the erect position. In this particular case the air bubble did not appear in the *x*-ray picture until about six hours after the clinical symptoms indicated perforation.

There is another misunderstanding attached to this gastrointestinal "blowout." Such is in the form of a dictum, namely, "bleeding ulcers don't perforate and perforating ulcers don't bleed." Such expressions, as a rule, are employed to offset some bad practice in vogue at the time they are made, and there probably was a time when doctors considered bleeding a necessary forerunner of perforation. Certainly there is no need for such a dictum now, for I doubt very much if there is a single one of the readers of this article who has not seen bleeding ulcers perforate and perforating ulcers bleed.

In about one-half of our cases it was difficult to obtain before operation any definite history that would suggest the existence of the ulcer before its perforation. Quite a few of our patients have had their perforations following an over-indulgence in food and fluids, often alcoholic in type. Most of these patients have been men, and even after operations for the closure of an opening, it has been difficult, and in quite a few instances, impossible to obtain any history that would indicate the existence of the ulcer before the actual perforation.

In only two of our seventy-one cases of acute perforations of peptic ulcers has there been any history of association of trauma with the perforation. The trauma in one of these two was due to an automobile accident, and in the other resulted from the impact of a plow handle when the point of the plow hit a large rock. Both of these accidents occurred shortly after the patients had over-indulged themselves at their midday meal, and when they probably had distended stomachs. Certainly the finding of large quantities of food, etc., in the peritoneal cavity when first opening the abdomen at least suggested that such was the case, and both admitted they had eaten unusually "hearty." Both of these patients had been treated for their peptic ulcers for several years before the time of the above-mentioned accidents, and therefore knew of the existence of their ulcers

before the accidental trauma aided in the perforations.

It has been stated that the treatment of ulcers by histidine prevents perforations. However, two of our cases with acute perforations were under treatment with histidine when this emergency occurred, and this in spite of the fact that this form of treatment is not very general in our community.

It is interesting to note that in these seventy-one cases of acute perforations of peptic ulcers, only thirty-two had been treated for their ulcers. Of the remaining thirty-nine it was possible to obtain histories of the previous existence of the ulcer in twenty-seven, but their symptoms were not severe enough, in their opinions, to require treatment. In the last twelve, even after the operation, we were not able to obtain any history that would indicate the existence of the ulcer before perforation, unless three patients who had been previously treated for some sort of "coronary occlusion" are included. None of these three have had any return of their cardiac symptoms since operation.

It is, I think, generally conceded, even by the most radical adherents of the non-surgically inclined of medical men, that properly executed surgery offers the best hope of recovery. If this statement is correct, then that brings up the consideration of what constitutes "properly executed surgery." Certainly the prevention of any unnecessary delay in the time of starting the operation is almost as valuable as prevention of rapid manipulations done in a rough manner during the operation. These break up early protective adhesions and increase the soiling of the peritoneal cavity. Sufficient time should be taken before operation for the insertion of a duodenal tube with suction through the nares as well as the giving of the correct intravenous medication to establish and maintain proper fluid balance.

While some of my surgical friends have found comfort in the employment of spinal anesthesia by obtaining freedom from abnormal respiratory movements being transmitted to the field of operation, it has been my observation that in the vast majority of cases the blood pressure in these patients after intestinal perforation is too low to justify such an anesthetic. Unless one is able to establish a mental equanimity concerning the margin of safety in the relationship of low blood pressure and spinal anesthesia, then the inhalation anesthetic to which the anesthetist is accustomed should be given. I feel I have some right to have a definite opinion in regard to this drug, for I have both experienced the comfort and lost the mental equanimity associated with spinal anesthesia.

The type of operation to be performed, of course, depends on the conditions found on opening the abdomen. Each case presents a separate individual problem, which requires the application of sound surgical judgment rather than dexterity. Extensive operative procedures should not be done in an infected field. If the history of the perforation is of sufficient duration to have allowed an extensive peritonitis to have developed, the less operating done in such a field the better for the patient. While the surgeon is isolating the perforation and applying whatever operative procedure he considers indicated, it should be the duty of an assistant to clean gently the peritoneal cavity, preferably by aspiration. It is important to aspirate the food and other gastric contents from the pelvic cavity and iliac fossae, to which such material so frequently gravitates.

Unless there is some very definite indication to the contrary, it is our practice simply to close the ulcer with No. 1 chromic catgut sutures. In a few cases, the infiltration surrounding the perforation has been so extensive, and the condition of the patient so precarious that we have sutured a small portion of the omentum over the opening. It is rather interesting, and perhaps instructive to notice how frequently in these cases the omentum is found in the neighborhood of the opening, as if it were attempting to plug or close the perforation

without "surgical aid"—somewhat in the way it behaves as regards an acute appendix.

There is apparently a tendency at the present time to institute operative procedures which will prevent the necessity of secondary operations. I am sure the sooner we surgeons realize that surgery can only be an aid, though often a most important one, in the treatment of "peptic" ulcers, the better such an attitude will be for the ultimate satisfactory condition of our patients.

The very natural and laudable desire on the part of the less experienced, but thoroughly conscientious surgeon, to prevent future operations will sometimes lead him to perform extensive procedures, into which a more experienced surgeon would not be tempted. Perhaps I have come to this conclusion by having had the opportunity on a few occasions to examine the pyloric openings some months after the closure of the perforation while doing operations for unrelated conditions. On these few occasions, I have been impressed by the small thin scar and the absence of adhesions around the site of the perforation. It is possible that the lack of adhesions might be due to the presence of digestive enzymes free in the peritoneal cavity at the time of perforation. In addition to these rather surprising sequelae, the pyloric opening has been found to be larger than normal, and the annular sphincter muscle less definite on palpation than is usually found when there has been no involvement by disease in this locality. Such findings naturally make one wonder if there might not have been an accidental division of the pyloric muscle by the actual perforation itself or by the infolding sutures cutting across this muscle during the weeks following the operation. However, in spite of these conjectural observations, about 6 per cent of our patients who have had only simple closures at the time of the primary operation, have required additional operations to relieve gastric retention or to aid in the medical care of the ulcer.

Some years ago we thought that a posterior gastroenterostomy at the time of the closure of the perforation gave relief from postoperative gastric distention. At the present time continuous suction through the small duodenal tube prevents gastric distention, and, therefore, this excuse for the addition of a gastroenterostomy no longer exists. We are now using this suction through the tube almost as a routine measure following all abdominal operations or other lengthy procedures. This practice has been of great comfort to our patients by almost entirely eliminating postoperative vomiting and "gas pains."

I am sure it is reasonable to presume that one of the reasons secondary operations are not more frequently necessary is to be found in the patient's willingness to cooperate in the subsequent medical treatment. The alarming surgical experience causes apparently confirmed cigarette smokers to shun tobacco as if it were poison, which it unquestionably is to many of them. A more general realization by both the laity and the profession of the causal relationship between cigarette smoking and "peptic" ulcer formation might prove to be a prophylaxis against this disease.

The solution of the question as to whether to employ drainage after these perforations is only another instance of selecting the proper procedure for the individual case. However, surgeons generally consider that drainage is not indicated in the vast majority of cases. It is a natural temptation to institute drainage, especially after finding a large quantity of food and gastric contents scattered around the peritoneal cavity, but one should recall the inhibitory effect of hydrochloric acid on the growth of bacteria and the fact that acidity is usually high in "peptic" ulcer cases.

Frequently drainage, if placed close to the site of closure of the perforation will be followed by the formation of a gastric or intestinal fistula with all its distressing results. The formation of such a fistula

leads to the gradual death of the patient often after some weeks of starvation of the body and painful digestion of the skin by the escape of gastric and duodenal juices. If the soiling of the peritoneal cavity has been great, and the resulting peritonitis extensive, we have made it a practice to close the peritoneum with interrupted catgut sutures, place silver wire splinting sutures through skin, fascia and muscle, and not tighten these sutures, but pack the incision with some antiseptic gauze. After several days, depending on the patient's general condition, this gauze is removed, and the through-and-through wire sutures tightened over buttons after the manner described by Shipley.

If the peritonitis has been sufficient to allow the formation of localized abscesses, these are drained by cigarette drains, but gauze is never placed near the site of the closure of the perforation.

HIPPOCRATES knew and described surgical conditions varying from congenital club foot to fracture of the spine. We have never improved on his clinical pictures.

TREATMENT OF ACUTE MASSIVE HEMORRHAGE IN PEPTIC ULCER

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ONE of the most important complications of peptic ulcer is gross hemorrhage. Manifested either by hematemesis, by melena, or by both, and often accompanied by the syndrome of shock and syncope, it constitutes a most alarming symptom and always causes the patient to seek medical care.

Because it is such an impressive symptom, fairly accurate statistics regarding the incidence of hemorrhage in gastric, duodenal, and anastomotic gastrojejunal ulcers can be obtained from the clinical histories of ulcer patients. The incidence in several large series indicates that about 20 per cent, or one in every five patients with peptic ulcer experiences one or more gross hemorrhages at some time during the course of his disease. Hemorrhage is relatively more frequent in gastric ulcers than in duodenal ulcers, and is even more frequent in the anastomotic or jejunal ulcers.

In spite of the alarming nature of the symptom, there has been a general impression held by the medical profession, that patients rarely died from gastric hemorrhage, and that the mortality from hemorrhage in peptic ulcer was negligible. This impression seems to have arisen from general experience, or more accurately, from generalized lack of experience with any large group of cases of gross bleeding from the gastrointestinal tract. In the last few years, reviews of the actual experience in hospital and clinic practice has shown that hemorrhage from gastric or duodenal ulcer incurs a distinct mortality, and that patients do occasionally bleed to death from a peptic ulcer. Blackford found in the vital statistics from the city of Seattle that in a two year period, there were 124 deaths from peptic ulcers, of which forty-two were recorded as being due to massive hemorrhage. However, the actual mortality rate associated with this complication has recently been a matter of considerable dispute. One has only to peruse the literature on this subject to become astounded at the marked discrepancy in the mortality statistics reported by various authors. There is no possible doubt but that these disparities, between the wide limits of 1.31 per cent and 58 per cent, are due largely to the study of dissimilar groups and to lack of application of uniform criteria of diagnosis and results. One finds some authors reporting on groups which include cases of cancer, ruptured varices, and acute gastric erosion. Some authors include occult bleeding under the diagnosis of hemorrhage, while others consider hematemesis only in their study. Many papers fail to state the relative incidence of mild and severe hemorrhages, or even reveal what criteria were used in judging the severity of cases. Differences in the clinical material from which the cases are drawn obviously introduces another variable factor in the calculation of mortality. A large metropolitan hospital furnishing an emergency and accident service, and serving a poorer class of population, might well be expected to receive a higher proportion of severe hemorrhaging cases than would be found in the experience of a private clinic. After a review of the literature, one must conclude that there are relatively few papers which offer any distinct aid in estimating the prognosis in gross hemorrhage from peptic ulcer.

Crohn and Lerner report a mortality of 6.5 per cent in a series of 215 patients treated medically and a total mortality of 11.6 per cent when they included seventy-

five patients who were operated on. This figure is probably considerably higher than the actual mortality rate of all cases of gross hemorrhage. The Mount Sinai group of cases which was studied by Crohn and Lerner undoubtedly contained a disproportionately high percentage of severe cases and severe hemorrhages, possibly occurring in a larger percentage of patients who are in generally poor condition.

Hurst and Ryle have pointed out that the only true mortality can be ascertained from statistics gathered by general practitioners, since they have the opportunity of seeing all cases of hemorrhage, either mild or severe, before they are segregated into hospitalized and non-hospitalized cases, medical and surgical cases.

The combined experience of twenty-seven practitioners in and around London was a total of 677 cases of hematemesis and melena with nine deaths, which was a mortality of 1.31 per cent. Since the method of collection of these figures is unknown and probably incomplete, a mortality of 1.31 per cent is probably lower than the actual figure. It would seem, therefore, that the general mortality rate for gross hemorrhage lies somewhere between 1.31 per cent and 11.6 per cent. Hurst, in reporting his experience in the medical wards of Guy's Hospital, found four deaths in a series of eighty-two cases of hemorrhage; a mortality rate of 4.8 per cent—which is well within the expected range.

We believe that the mortality rate reported in this paper is closely approximate although it does not actually represent the general mortality rate for gross hemorrhage from peptic ulcer. We have included only cases in which the diagnosis of gastric, duodenal or anastomotic ulcer was reasonably certain. We have included mild cases of gross hemorrhage as well as severe cases, but did not include any case that did not have vomiting of at least several ounces of blood or the passage of one or more definitely tarry stools. No case of occult bleeding alone was included. We did not include cases with a history of gross hemorrhage unless it occurred within six days before admission to the hospital. Our figures, therefore, represent the mortality of a group of patients who had the advantage of being treated in a hospital, but of course these figures must be interpreted in the light of certain factors which influence the type of case which comes to the Lahey Clinic.

In our opinion, the most useful clinical criteria in estimating the severity of a hemorrhage are the presence or absence of fainting, syncope or other symptoms of shock. The most dangerous feature of hemorrhage is the rapid decrease in blood volume. Patients who have a slow hemorrhage can tolerate a reduction of hemoglobin to a very low level, providing there is time for physiologic adjustment of the blood volume. Therefore, collapse, fainting and fall in blood pressure are indications of a hemorrhage which is of serious importance as compared to bleeding which does not cause such symptoms.

In the group we are reporting here there were 108 cases treated for acute gross hemorrhage, including duodenal, gastric and anastomotic ulcers. Of this group there were forty-seven mild cases and sixty-one severe cases. In the entire series of 108 cases, there were five deaths, a mortality of 4.6 per cent, and we believe this figure closely approximates the true mortality rate of gross hemorrhage due to peptic ulcer.

The treatment of bleeding peptic ulcer is one requiring considerable experience and a nicety of judgment in the handling of these cases. The problem of treatment is certainly not whether hemorrhage should be treated by medical or surgical methods, but is the determination of what system of management for each individual case will result in as few deaths as possible from this serious complication of ulcer. Unquestionably, there is a small group of patients with bleeding ulcers who must come to surgery and whom operation alone can save. However, it is our opinion that the majority of cases can be handled conservatively without the necessity of applying surgery.

The method employed in the Lahey Clinic in the conservative treatment of hemorrhage from ulcer consists of a régime which has been generally accepted and practiced for a number of years. It is essentially an expectant and conservative régime consisting of rest in bed, morphine in doses large enough to produce adequate sedation, starvation for two or three days and then a gradual application of the Sippy diet.

In recent years the most important new therapeutic measure has been blood transfusion, but there has been lack of general agreement as to its value. Many clinicians feel that there is a distinct danger in the giving of a blood transfusion on the basis that a possible rise in blood pressure may produce a blow-out of the thrombotic plug in the bleeding vessel, causing secondary hemorrhage.

In this clinic, blood transfusions have been used rather more freely than elsewhere for two distinct indications: first, to correct the acute loss of blood volume, and second, as a treatment of secondary anemia merely to shorten the patient's convalescence from a severe blood loss. Patients who die suddenly from the first outpouring of blood are rarely in the hospital and consequently the question of transfusion does not arise. The usual severe case of hemorrhage admitted to the hospital ward is the patient who has survived the shock of a severe blood loss, but who still presents the clinical picture associated with a marked reduction in blood volume below normal. Although life is being maintained, there are two distinct dangers associated with this condition. The first is danger of a secondary hemorrhage which in some cases is possible even though the blood pressure may be markedly lowered. If this occurs in the case of an already markedly reduced blood volume, the additional loss of blood may be suddenly fatal. The second and what is probably the most important danger, is the effect upon function and possibly irreparable damage which takes place in vital organs as a result of long continued reduction of blood pressure and blood volume. One of the most outstanding laboratory evidences of this is the high nonprotein nitrogen frequently found associated with severe hemorrhage; this in some cases actually appears to be important in the cause of death. The brain, heart and liver are probably also affected, but this is not so easily demonstrated in the laboratory.

It would seem therefore that the danger of causing a secondary hemorrhage by giving a blood transfusion is distinctly less than the danger associated with letting the patient's condition remain at a low level too long. It has been our experience that a small or moderate size transfusion of citrated blood given slowly by the drip method has been safe and of distinct value. We have not seen a sudden rise of blood pressure following transfusions, but we have seen the gradual rise of blood pressure from a dangerously low level, that is below a systolic pressure of 90 mm.

The decision as to whether a transfusion is indicated or not cannot be based upon the examination of the blood count, since blood volume can be reduced to a dangerously low level without making an appreciable change in the red blood count or the hemoglobin determination. The changes in these values do not take place until after the blood volume has been at least partially corrected by dilution with body fluids. Clinical estimation of the patient's condition depends upon the pallor of the skin and mucous membranes, the rate and quality of the pulse and upon the blood pressure, with additional consideration given to the estimated quality of blood that has been expelled. No arbitrary rule can be followed, but a fall in systolic blood pressure to 90 mm. or below and a rise in pulse rate to over 130, particularly when there has been definite evidence of a large amount of blood loss, are indications for a transfusion.

The same criticisms may be applied to the use of intravenous and subcutaneous injections of glucose or saline solution. They are useful, however, when dehydration is severe and apparently they do allay

thirst to some extent during the starvation period. However, patients who are well morphinized do not complain much of thirst as a rule. If intravenous fluids are introduced slowly, the blood volume may be increased without appreciably raising the blood pressure, but on theoretical grounds at least, this is less desirable than by means of a transfusion since the viscosity of the blood is decreased and there may be a disturbance in the clotting mechanism brought about by the dilution.

Diet in the treatment of hemorrhage in peptic ulcer in this clinic and until recently generally accepted as a time honored method of treatment, consisted of starvation or the elimination of both food and water for a period before the gradual institution of the Sippy type of ulcer régime. In 1933, Meulengracht upset all previously conceived ideas as to the treatment of gastrointestinal hemorrhage by reporting that he obtained a marked reduction in mortality by beginning liberal and early feeding during or immediately after the bleeding. It was his opinion that early feeding preserved the strength and nutrition in a patient and brought about a more rapid convalescence and in this way reduced the mortality figure. He reasoned that the food had therapeutic value in neutralizing the gastric acid, thereby favoring healing of the ulcer and preventing digestion of the clot in the bleeding vessel. His diet consists of meat, fish, puréed vegetables, bread and butter, cheese, tea and cereals. In 1935, he reported 251 cases of hemorrhage taken to be due to genuine ulcer with only two deaths; a mortality of less than 1 per cent. He did not give his criteria as to the severity of the hemorrhages nor do we know from his report anything of the factors which might influence the relative incidence of severe and mild cases. He does compare his results with those of Christiansen and another hospital in Copenhagen, which appear to have an identical type of case and treated in the orthodox way. In this group there was a mortality of 7.9 per cent in 289 patients.

Meulengracht's report has attracted wide attention and many clinics have modified their treatment of hemorrhage along these lines, but as yet there are few reports which give the results of any sizable series of cases. In the Lahey Clinic we have not yet changed over to the Meulengracht method of treating hemorrhaging cases, although in principle we follow his ideas to some extent. We do not starve the patients for any extended number of days, although it is our opinion that for forty-eight to seventy-two hours after a diffuse hemorrhage the stomach should be put at rest as nearly completely as possible. It is indeed a rare patient whose nutrition would suffer seriously from a starvation period of this length. If at the end of two or three days there is no evidence of a repetition of bleeding, it seems highly desirable to start therapeutic measures directed towards neutralizing gastric acidity, promoting healing of the ulcer. Although Meulengracht reported a 1 per cent mortality rate, it probably does not represent uniform results to be expected from this type of treatment. Yet, it is significant that he has observed a very definite and marked reduction in his mortality following this radical change in treatment.

Alkalis and other forms of anti-acid therapy should be used as in the routine management of an active ulcer. Starting the régime, however, it is necessary to observe precautions to avoid overloading the patient with too large a volume of food and medicine. The treatment of the secondary anemia should not be delayed, and the patient's convalescence can be hastened by the administration of sufficient iron. We have used chiefly ferrous sulfate in doses of 6 gr. three times a day.

Morphine is the drug most commonly used for sedation in dosages of $\frac{1}{6}$ to $\frac{1}{4}$ gr. every four hours, depending upon the quantity necessary to keep the patient immobile and asleep most of the time. The

patients who react to morphine with nausea and vomiting and nervous irritability may be given hypodermic medication of soluble barbiturates in dosages sufficient to obtain the desired results.

There has been some reported evidence suggesting a relationship between subclinical avitaminosis C and bleeding ulcer, but the importance of this relationship is still unsettled. In cases which show definite increase in capillary fragility above normal, vitamin C medication given parenterally would seem to be indicated. At present there is little evidence that the resistance of the blood vessels can be increased above normal by the administration of vitamin C. Furthermore, severe bleeding in peptic ulcer is not usually a capillary type of bleeding.

The use of hemostatics, vasoconstrictors and astringents has fallen into disrepute, and there is little on either theoretical or clinical grounds to support their use. The hemorrhage in peptic ulcer is not caused by failure of the blood to clot, but is due to the mechanical opening of the vessel. Furthermore, there is always the danger that the administration of such medication may cause vomiting or other disturbances which are distinctly detrimental to the cessation of bleeding.

Clinical decisions in any given case of severe hemorrhage must be based upon an estimation of the disease present, upon knowledge of all the factors which influence the prognosis and an accurate appreciation of just what can be accomplished in the way of treatment, whether it be medical or surgical. Nearly all of the severe and fatal cases of hemorrhage in duodenal ulcer occur from large posterior wall adherent ulcers with erosion of the pancreaticoduodenal artery. Hemorrhage which occurs in a long-standing chronic ulcer is apt to be serious since the abundant scar tissue interferes with the retraction of the eroded end of the artery. Large gastric ulcers situated on the posterior wall and eroding into the pancreas also give rise to the most severe type of hemorrhage. Hypertension and arteriosclerosis are complicating factors which tend to aggravate hemorrhage. In hypertension the unduly elevated blood pressure may dislodge the clot repeatedly, and in arteriosclerosis there is loss of retractility of the vessel walls. The influence of sex and age upon the prognosis of gross hemorrhage has been repeatedly pointed out. Many authors have observed that the mortality in patients over the age of 45 or 50 is four or five times that of patients below this age. It has also been noted that women rarely die from hemorrhage in ulcer. In our clinic and in several other clinics, there has not been a fatality in women from such a cause.

Adequate and intelligent nursing care is essential to keep the patient at rest and to watch for signs of further bleeding. Hourly observations of the pulse rate and blood pressure are particularly useful. A sudden fall in blood pressure, a rise in pulse rate or other signs of collapse must be interpreted as indicating secondary bleeding even though there is no hematemesis or melena.

In our experience the occurrence of signs and symptoms indicating recurrent or secondary hemorrhage while the patient is on a complete hemorrhage régime is a serious omen and is an extremely important prognostic sign. When there is recurrent hemorrhage while under treatment, particularly if it is accompanied by signs of shock, it indicates that a large artery branch has been opened and that the retraction of the eroded ends of clot formation is inadequate. When this occurs in a patient who has had a long history of a severe ulcer, and who probably has a chronic indurated duodenal lesion, particularly in a male over the age of 50, the significance of this clinical course is emphasized.

When it is obvious with continuation of bleeding that a large artery is the source of hemorrhage or when continuous drip transfusion or repeated transfusion has failed to control the bleeding or to keep the blood pressure at a reasonable level it is then apparent that immediate operation may

prove to be necessary to prevent a fatal outcome.

The decision for employing surgery in a case of bleeding ulcer is a serious matter and requires the utmost coöperation between the internist and the surgeon. Certainly, early consultation between the internist and surgeon is a most desirable feature and it should be emphasized that this consultation should not be delayed until operation is recommended on the basis of a last desperate effort to save the patient's life. There can be no question that it would be distinctly wrong to advocate operation for the treatment of acute massive hemorrhage occurring from all gastric and duodenal ulcers. Should such a course be followed it would result in many deaths. We certainly would not advocate or recommend that all patients who have bleeding from peptic ulcers should have operation within forty-eight hours. For such a policy to become widespread or in general use as advocated by some surgeons would be serious indeed. Certainly such surgery should be carried out only by surgeons having considerable experience in gastric surgery and in large hospitals which are sufficiently equipped to permit emergency surgery of that character to be performed with reasonable safety. Furthermore, a sufficient number of donors should be at hand to provide any amount of blood that may prove to be necessary to the patient during such an operation.

Lahey has described two distinct types of acute hemorrhage occurring in patients with peptic ulcer and the recognition of these types has proved of great practical benefit to us in determining which case may possibly require surgical intervention. The first and more frequent type is that in which a single hemorrhage occurs, evidenced by the vomiting of blood or by passing a large tarry stool, in conjunction with varying degrees of shock. The hemorrhage may continue or may be repeated during the following twenty-four or thirty-six hours, but with the application of conservative medical measures the bleeding ceases and does not recur. With this type surgery will not prove to be necessary.

There is another type of massive recurrent hemorrhage in which large amounts of blood are lost by vomiting or by stool, in which the hemorrhage is continued or repeated again and again on the same day or during the following days, in which serious blood loss is evident by a fall in blood pressure, which is uncontrolled by repeated blood transfusions or continuous blood drip. It is obvious that unless something can be done early a fatality will certainly result.

There is danger in delay in such a case, and it is generally accepted that the mortality in surgery mounts rapidly as the patient becomes more and more exsanguinated. If it can be definitely established that the patient is having recurrent gushing hemorrhages in spite of a complete and adequate medical régime, transfusions and operation should be done. It would be highly desirable if this type of patient could be operated upon within forty-eight hours of his first hemorrhage, but it is scarcely possible to do this in all cases and still allow time to determine whether or not he is having secondary hemorrhages. We cannot entirely agree with Finsterer, who is the chief advocate of surgical treatment for acute hemorrhage, in his practice of operating upon all patients who have passed middle age who have a severe hemorrhage, even though his reported mortality in early operations compares very favorably with the medical mortality in this group of cases. It seems very unlikely that Finsterer's low mortality rate of 5.1 per cent could be duplicated by more than a very few surgeons.

Such serious hemorrhages usually result from an erosion of the pancreaticoduodenal artery at the base of a penetrating ulcer of the posterior wall of the duodenum, or an erosion of the left gastric artery or of the gastro-epiploic artery in a gastric ulcer on the posterior wall of the stomach which may perforate into the body of the pancreas. This type of hemorrhage usually

occurs in a patient with chronic callous ulcer with rigid ulcer base. In the majority of cases the patient is a male over 50, with sclerotic arteries. Too early and ill-considered surgical interference in these cases cannot be too heartily condemned.

Surgical interference should be designed primarily to control hemorrhage and except in a few cases need not include removal of the ulcer or be designed to effect permanent cure of the ulcer condition.

If the patient's condition is such, if the experience at hand is sufficient and if the equipment is adequate to proceed with more radical surgery, we believe that removal of the ulcer with a high resection of the stomach of the Hofmeister type should be carried out. However, in conditions where such an extensive surgical procedure would be very likely to result in a fatality, a more conservative method of handling the situation should be employed.

Gastroenterostomy alone is not a satisfactory operation to control bleeding from an ulcer and is rarely used or advised. The effect of such a procedure in controlling hemorrhage is an indirect one because it presumably places the pylorus and duodenum at rest and permits continuous emptying of the stomach through the gastrojejunal stoma.

The majority of patients with severe hemorrhage requiring surgical interference will be found to have bleeding from arteries of large caliber such as the pancreaticoduodenal or other arteries which so abundantly anastomose about the head of the pancreas.

The type of ulcer which is associated with much induration, with extensive periduodenal adhesions, makes simple ligation of the main trunks of the arteries supplying the pylorus and duodenum a difficult and most uncertain procedure. (Fig. 1.) To ligate the right gastric artery or the gastroduodenal artery may not be sufficient to establish hemostasis and fatal hemorrhage may result from the numerous anastomoses of arteries about the head of the pancreas.

In the case of hemorrhage resulting from a duodenal ulcer, if the patient's condition does not warrant a removal of the ulcer,

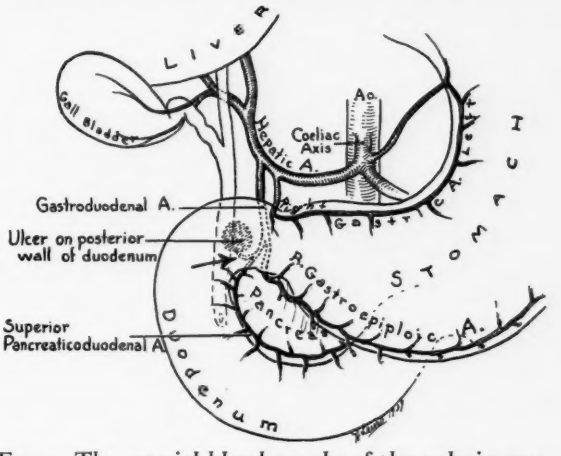

Fig. 1. The arterial blood supply of the pyloric area of the stomach and duodenum. The relationship of a posterior wall duodenal ulcer to large arteries is noted.

with a high resection of the stomach it is the practice of this clinic to proceed with a transduodenal ligation, with silk transfixion sutures, of the bleeding vessels and to accompany this procedure in most cases with a gastrojejunostomy.

The method of procedure is as follows: A high left rectus incision is made, of sufficient length to permit ready exploration of the upper abdomen. The situation of the ulcer which is the source of hemorrhage is readily determined in the majority of cases by examination of the stomach and duodenum. In an occasional case it may be difficult to determine the presence of an ulcer on the posterior wall of the duodenum and incision of the anterior wall of the duodenum may be required to demonstrate the source of the hemorrhage.

Should the blood be issuing from an anterior wall lesion, this would be obvious upon inspection and in the majority of cases such an ulcer can be excised by a longitudinal incision along the axis of the duodenum, extending through and above the pyloric ring; all bleeding points are ligated and a pyloroplasty is made by closing the incision transversely.

However, when the hemorrhage results from a deeply penetrating ulcer on the

posterior wall of the duodenum the superior and inferior borders of the duodenum and pyloric area are grasped by tacking forceps and an incision is made into the duodenum and extended above the pylorus for about an inch, opening the duodenum widely. The duodenum and stomach are aspirated to avoid spilling stomach contents, and the source of the hemorrhage can be easily determined. In most cases the blood will be seen to be issuing from an artery of large caliber at the base of the ulcer. The bleeding may then be controlled by mattress sutures of heavy silk introduced into the posterior wall of the duodenum (Fig. 2) and including the edges of the ulcer base. We advise the employment of a nonabsorbable material for this suture because with one patient we had recurrence of hemorrhage ten days after ligation, due to the digestion of the catgut suture material. In this case reoperation with removal of the ulcer-bearing area of the duodenum and a high resection of the stomach was completed, with recovery of the patient.

Following the ligation of the ulcer base the rent in the duodenum and pyloric area is closed transversely, thus performing a typical pyloroplasty. In the event of considerable scarring and contraction of the duodenum with resultant narrowing of the lumen, a posterior gastrojejunostomy is always employed.

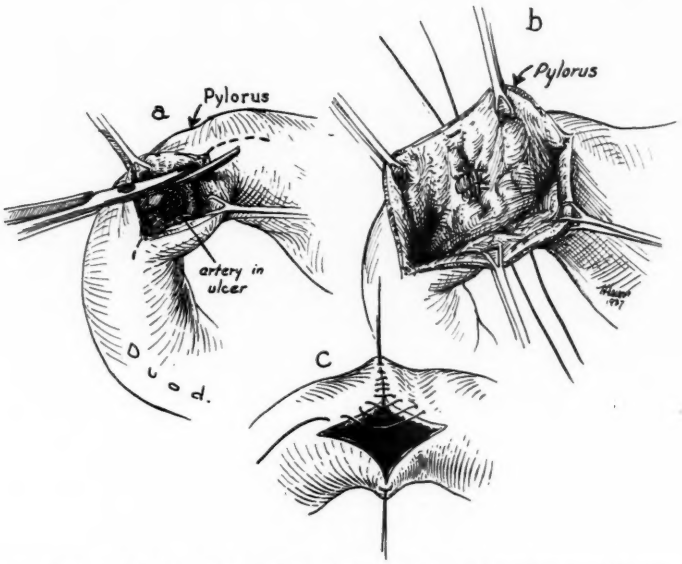

FIG. 2. Transduodenal ligation of bleeding vessel in ulcer on the posterior wall. *a*, incision opening the duodenum extended past the pylorus for about 3 cm.; *b*, mattress sutures of silk are introduced through the base of the ulcer to control hemorrhage; *c*, pyloroplasty performed by closing the incision transversely.

If, however, upon exploration examination of the stomach and duodenum discloses the hemorrhage to be issuing from a gastric ulcer on the posterior wall of the stomach which has penetrated into the pancreas, the stomach is freed from the pancreas and from the base of the ulcer, the bleeding vessels are ligated, the margins of the ulcer are excised from the stomach wall, and the rent in the stomach is simply closed by suture without gastroenterostomy. If the ulcer proves to be on the lesser curvature and resection is considered impossible because of the patient's condition, a simple excision of the ulcer with closure of the opening in the stomach is performed. In this event a posterior gastroenterostomy is always employed to avoid interference with gastric emptying.

However, if the patient's condition following massive blood transfusions before

and during operation permits resection of the stomach, we prefer to remove the ulcer, whether duodenal or gastric in origin, and proceed with a high resection, that is, removing with the ulcer three-fourths to four-fifths of the stomach and performing a gastrojejunostomy of the antecolic Hofmeister type. (Fig. 3.) It is evident that the conservative operative procedure such as outlined above may fail to relieve ulcer distress permanently, or prevent recurrent hemorrhage. Permanent relief is more apt to follow a high resection of the stomach with removal of the ulcer area, but this is not always possible because of the serious condition of the patient at the time that operation is carried out. Certainly if conservative operative methods are employed and if the patient has a recurrence of symptoms upon a good ulcer régime, a high resection of the stomach should be advised and carried out as early as possible.

In preparation for such an operation a method for infusion of blood into the patient to control blood pressure and partially to restore blood loss must be provided for. Immediately before operation a Hendon cannula is tied into the long internal saphenous vein in the ankle and during operation a continuous drip transfusion of blood is given. This method has proved thoroughly reliable and satisfactory.

The type of anesthesia employed in these cases is a regional block of the abdominal wall, obtained by infiltration with 0.25 per cent novocain solution, which may be supplemented if necessary with a light cyclopropane gas anesthesia. Cyclopropane gas oxygen anesthesia is of especial value to supplement regional block because of the high oxygen concentration (80 to 85 per cent) which may be desirable in view of the anemia resulting from blood loss. If the patient's blood pressure is controllable at a reasonable level by the rapid infusion of blood and his condition is reasonably good we prefer to employ a dilute nupercaine solution; 1:1500 dilution, as a spinal anesthetic. This form of spinal anesthesia can be safely employed in most patients and is a much more adequate anesthesia in the event that a high resection of the stomach with removal of the ulcer can be used in the particular case.

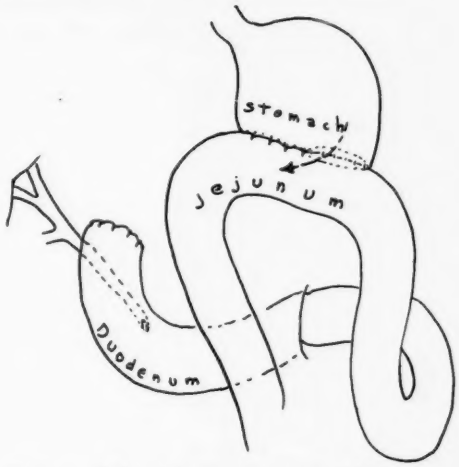

Fig. 3. Subtotal gastrectomy, Hofmeister method. The ulcer is removed and high resection of the stomach is done. The jejunum is brought anterior to the colon. The gastrojejunal stoma is indicated by a dotted line. This is the operation of choice for bleeding ulcer if the patient's condition will permit.

SUMMARY

Acute massive hemorrhage from peptic ulcer is a serious complication, particularly in patients with chronic, callous ulcer.

In a series of 108 cases of massive hemorrhage of peptic ulcer in the Lahey Clinic, there were five deaths, a mortality of 4.6 per cent.

In the majority of cases the method of treatment employed in acute hemorrhage from peptic ulcer is a conservative régime consisting of rest in bed, morphine in doses large enough to produce adequate sedation, starvation diet for a few days, and then a gradual application of the Sippy régime.

Surgical management is employed in a very small group of cases in which there is continuous bleeding from an erosion of a large caliber vessel, uncontrollable by conservative measures.

The operation of resection of the stomach with the removal of the ulcer is the operation of choice, provided the patient's condition will permit it. If resection cannot be employed, a more conservative procedure

is followed, such as transduodenal ligation of the eroded vessel in duodenal ulcers, or an excision of a gastric ulcer, with or without a gastroenterostomy.

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Much of Galen's surgery was learnt on the battered bodies of gladiators, for their care was entrusted to him by the Pontifex of the Games in Pergamos. . . . As he gained experience of (tendon) injuries which were apparently very common among the gladiators in his charge, he began to suture the ruptured ends of the tendons in certain cases.

STRANGULATED HERNIA

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ONE of the common causes of acute intestinal obstruction is strangulation of an external hernia. Since this condition constitutes a surgical emergency, its prompt recognition and a thorough knowledge of the principles of treatment should be a part of every surgeon's training.

While strangulation may complicate the rare or unusual forms of hernia, such as obturator, sciatic, lumbar and diaphragmatic, it is seen much more frequently in the commoner varieties, i.e., inguinal, femoral, umbilical and postoperative ventral.

Diagnosis. Except under unusual circumstances, the diagnosis is not difficult. In every case of suspected acute abdominal condition, especially if symptoms of intestinal obstruction are present, a meticulous examination of the external orifices should be made. This is imperative because, in addition to the symptoms common to intestinal obstruction from other causes, strangulated hernia presents a painful, tender, tense mass or swelling at the site of one of the external hernial openings. Not infrequently the patient is unaware of the existence of the hernia. This is particularly true of the femoral variety, although usually a previous history is obtainable.

Pathology. For the most part, hernial openings have a firm, fibrous, unyielding margin which may compress the imprisoned viscus. When the pressure is sufficient to impair the venous return, engorgement and further swelling rapidly supervene. Unless relieved, the blood supply is further impaired, necrosis becomes inevitable, and gangrene and perforation follow. The hernial sac becomes filled with a transudation which at first is blood-tinged and later frankly bloody. Bacteria pass readily through the wall of the intestine during the later stages of this strangulating process so that the fluid may be turbid and cultures taken therefrom yield a growth of the B. coli group.

In addition to the local changes, a general abdominal distention results from the complete interference with the flow of the fecal current, and with the distention all the clinical manifestations of acute mechanical ileus are seen, viz., vomiting, toxemia, dehydration, and lowered plasma chlorides.

The mechanical effect of an acute partial enterocele, or Richter's hernia, is such that firm pressure cuts off the blood supply to only a portion of the circumference of the bowel (usually the small bowel) without obstructing completely the passage of intestinal contents and gas. Hence, such a condition may result in gangrene and perforation without the classic distention and toxemia which other forms of strangulation induce. This variety of strangulation is most often seen in femoral hernias when a small segment of the bowel is nipped by the particularly unyielding edges of the femoral ring. Where the contents of the sac consist solely of omentum, vomiting may be a symptom, but distention and toxemia are usually less prominent.

Reduction en Masse. This rare complication of strangulated hernia usually follows persistent and vigorous attempts at manual reduction. In a typical case, early unsuccessful efforts at reduction are suddenly followed by a sensation of "slipping back" of the hernia together with a disappearance of the mass. Instead of complete relief of symptoms, there is a persistence thereof, accompanied by concomitant signs of obstruction which become progressive. In such a case, laparot-

omy reveals an inverted sac which still constricts at the neck the segment of bowel. Since the obstruction persists, it is obvious that gangrene and perforation will follow unless relieved by prompt exploration. That this unusual condition is not often recognized and, therefore, has a high mortality rate is due to the fact that it is seldom suspected.

Treatment. Preventive treatment must be regarded as one of the practical ways in which a lowering of the mortality rate may be accomplished. In periodic health examinations, as well as in those made prior to employment, it should be the aim of the examining doctor to detect a hernia in its early stages and to recommend operative correction. It is unusual for a hernia to make its first appearance late in life, but procrastination or ignorance causes many individuals to encounter strangulation at an age when operation carries a greater risk.

Once the condition of strangulation has been recognized, valuable time should not be lost by attempts at manual reduction, for with each hour's delay the prognosis is adversely affected. Taxis is safely used only in cases seen early; in general, it is not to be recommended. The danger of reduction of a nonviable segment of intestine or the rare "reduction en masse" must be borne in mind.

Operative Procedure. The first aim of operative treatment is to release the imprisoned intestine (or other viscus) from its constriction. To accomplish this promptly and with as little manipulation as possible requires adequate exposure; consequently small incisions are to be condemned. After the sac has been opened and its contents inspected, one must decide whether or not the condition of the bowel will permit of its return to the abdomen. Here surgical judgment based on experience is essential. If the gut is lusterless, sodden, lacking in peristalsis and without pulsation of the mesenteric vessels, then exteriorization or resection is imperative. If, under the influence of warm, moist pads, the dusky color changes to a more normal appearance, then it is viable and may safely be returned. In cases at either extreme, a decision is not difficult. In borderline cases, however, the decision may be a delicate one. In general, if after ten or fifteen minutes have elapsed, there is still a question in the mind of the surgeon, it is wisest to exteriorize the involved loop. Whenever during the preliminary stages of the operation, spontaneous reduction of the contents occurs before a decision as to their viability has been reached, it is advisable, after repair of the hernia, to perform an exploratory celiotomy and to scrutinize carefully the previously strangulated loop. If resection is necessary. it can then be performed far more easily and safely. This precaution is necessary to avoid perforation of the non-viable gut and ensuing peritonitis. As to whether exteriorization or resection is indicated, one must weigh the patient's chances of surviving secondary procedures if the former is chosen, against the greater risk of immediate resection in the presence of toxemia, distention and dehydration. If resection is decided upon, it is often best performed through a separate incision after the strangulation has been relieved.

Illustrating the problem of decision between enterostomy and resection, the following personal case is cited:

J. K., male, aged 48, a garage worker, was admitted to the Second Surgical Division, Bellevue Hospital on November 5, 1926, complaining of violent and persistent vomiting associated with cramp-like pains in the abdomen, and obstipation. Examination revealed a moderately distended abdomen, rather tender and tympanitic. There was generalized muscular rigidity, not board-like in character, however. In the right groin, apparently along Poupart's ligament, there was a globular mass vaguely outlined beneath the thick layer of fat. The mass was somewhat indurated and there was a faint pink blush on the overlying skin. It was not reducible, gave no impulse on coughing, and was exquisitely tender to palpation. During the examination the patient

vomited offensive-smelling brownish material in large amount.

Leucocytes numbered 25,350; polys 94 per cent, transitionals 2 per cent, lymphocytes 4 per cent. Urinalysis was negative except for two plus albumin. Temperature was 99 degrees, pulse 120, respirations 20.

An immediate operation was performed under 1 per cent novocaine anesthesia. A right femoral sac was exposed which, when opened, revealed a Richter's hernia in which about three-fourths of the circumference of the gut was markedly devitalized. On the contramesenteric aspect a greenish area of gangrene and softening was present. While there was no evidence of actual perforation, a distinctly foul odor was apparent when the sac was opened. This hernia represented a type that is often described as an acute partial enterocele.

An inguinal incision prolonged downward over the femoral opening was made and the subcutaneous fatty layers overlying the femoral sac were divided; the sac was exposed and opened. An attempt was made to draw down the bowel to inspect the gut above the point of constriction but this, even after Gimbernat's ligament had been divided, was unsuccessful, owing to the fact that the gut seemed to be on the point of rupturing. The inguinal approach was then resorted to, and with the peritoneal cavity opened, bimanual efforts to reduce the gut were successful. Because of the patient's critical condition, resection was not carried out. The gangrenous loop was sutured into the upper opening in the peritoneal cavity preparatory to drainage of the bowel. A rubber dam drain was placed in the lower angle of the incision leading to the site of the gangrenous femoral sac which was previously excised.

Less than twenty-four hours later, an opening was made in the loop of gut which had been brought outside the abdomen and catheters were inserted in both limbs of the U. A prompt and copious discharge of foul-smelling intestinal contents, followed by relief of distention and other symptoms of obstruction, took place. The abdominal wall quickly became excoriated and an area 7 or 8 inches in diameter extending up to the umbilicus was within a few days raw and exceedingly painful. Attempts to protect the skin with kaolin and glycerine pastes were unsuccessful, and the patient grew weaker through loss of nutrition due to the high position of the enterostomy. Therefore, one week later, November 12, 1920, it was decided to attempt a closure.

By finger dissection, the loop of gut with its opening was easily freed from the adherent muscle circumferentially. Traction on the loop withdrew the gangrenous portion for a distance of 3 inches on the proximal side and 4 or 5 inches on the distal side. As this was insufficient on the proximal side to permit a suture resection, the involved section was excised and anastomosis by Murphy button was performed. After the button had been closed, a further supporting peritoneal layer of continuous plain catgut No. 0 was introduced to perfect the serosa-to-serosa approximation. The anastomosis was then pushed within the abdomen and a large Mikulicz rubber dam tampon was placed in the opening through the abdominal cavity and held by very carefully applied dressings maintained with many tail binders.

Subsequent Course. Following the second operation, the patient rapidly improved. There was no distention and the inflammatory condition of the abdominal skin rapidly yielded to treatment with zinc oxide ointment. The Mikulicz tampon was repacked daily and as the wound closed its contents of packing were reduced and finally removed. Granulations filled the area of depression and the wound healed.

Pathologic Report of Femoral Sac. The sac consisted of edematous fat and areolar tissue thickly infiltrated with polynuclear cells. The diagnosis was acute infiltration, fat and areolar tissue. A culture taken at operation was sterile after seventy-two hours.

This patient was lost track of after June 29, 1927, but at that time he was in excellent condition with no subjective symptoms.

TECHNICAL CONSIDERATIONS

Anesthetic. A local or a spinal anesthetic is desirable in adults. If a general anesthetic is used, the stomach should be emptied with a duodenal tube which may be left in place during the anesthesia period. If this precaution is neglected, the patient may regurgitate and inhale sufficient material to cause serious pulmonary complications; in extreme cases he may literally be drowned during the operation. For infants and young children we prefer open drop ether rather than local or

regional anesthesia. Avertin may be used as a basal anesthetic unless there are contraindications.

Operation. The primary aim of the operator is always to relieve the strangulation and to restore the viable contents to the abdomen as speedily and as gently as possible. To this end, a generous incision and rapid sharp dissection with a minimum amount of tissue trauma from rough handling are desirable. Provided the condition of the patient permits, repair of the hernia should then be carried out as meticulously as in a non-strangulated case. The additional time required for the repair itself should not exceed ten minutes.

Femoral hernia repair in cases of strangulation deserves special consideration. The operator should familiarize himself with the inguinal approach for femoral hernia because in strangulated cases this method is particularly important. The reasons are twofold: (1) it aids greatly in the reduction of the hernial contents and at the same time exposes them for thorough inspection as well as for rapid and safe resection if required; and (2) it enables the operator to repair the femoral opening by suturing Poupart's ligament to Cooper's ligament from above, thereby closing the opening from within. Most recent writers are impressed with the superiority of the inguinal or high approach especially as applied to operations for strangulated femoral hernia.

Postoperative ventral (incisional) hernia may, when strangulated, offer almost insurmountable difficulties. This is due principally to the extensive adhesions that may glue the loops of intestine to the interior surface of the sac as well as to each other. Patience and fortitude are often required for the successful performance of such an operation. It may be good judgment to relieve the constriction, reduce the contents attempting to free each adhesion, and close the abdominal wall as carefully and rapidly as possible. Even if every existing adhesion were faithfully divided, it is more than likely that many new ones would soon be formed.

Inguinal Hernia in Infants. Ever since Dowd (1898) reported a successful operation for strangulated hernia in an infant, at the same time alluding to previous cases collected from the literature, surgeons have recognized that there is no age limit to a favorable outcome. These little patients stand surgery remarkably well, provided it is done rapidly, gently, and with a minimal loss of blood. Early operation is of paramount importance; delay diminishes the chance of survival by almost geometrical progression. Small infants do not withstand well the prolongation of operating time incidental to enforced resections. It is axiomatic that an operation should be undertaken before a lapse of time results in the contents becoming non-viable.

Sliding Hernia. When, as rarely happens, a strangulated sliding hernia of the cecum or sigmoid is encountered, the operator is apt to become confused. Only infrequently is a satisfactory high closure of the sac obtained even when the Hotchkiss operation is employed to construct a new mesentery for the sliding component. In such cases, prompt cord division, as recommended by Burdick and Higinbotham, has in our hands greatly simplified the hernial repair. This can be made tight from one end of the inguinal canal to the other, thus compensating for the unsatisfactory disposition of the sac.

Internal Hernia. In contradistinction to the far more common instances of strangulation of external hernia, reference at least must be made to the rare varieties of internal strangulation, such as, hernia through the foramen of Winslow, paraduodenal hernia, pericecal hernia, intersigmoid hernia, obturator hernia, sciatic pudendal hernia. In general, these hernias are operated upon under the diagnosis of *intestinal obstruction.* It is most unusual for a correct preoperative diagnosis as to locality to be made. The surgeon, however, should bear in mind the possibility of a hernia occurring at any of these different locations and recognize it at once when encountering intestinal obstruction at lap-

arotomy. While it is not within the scope of this paper to discuss each of these various types of internal hernia, suffice it to say that early exploration and relief of the obstruction is the important desideratum.

Enterostomy. Exceptional cases seen late in the course of the disease, with frank gangrene and with the patient in a critical condition may require enterostomy. In these, the performance of resection and suture anastomosis is one which, while greatly to be preferred, is too formidable a procedure. It is better judgment to deliver the gangrenous loop outside the abdomen and to place rubber tubes in both limbs of the loop. Where small intestine is involved the resulting excoriation of the abdomen from irritating intestinal contents and the rapid loss of strength of the patient demand further attempts to close the bowel as soon as all symptoms of obstruction have been relieved. So manifold are the complications of a small intestinal enterostomy of this type, and so hazardous are the later surgical attempts to relieve it that one is justified in choosing resection at the original operation even when the patient's condition seems desperate.

Postoperative Care. If skill is required to bring the patient through the actual operation, it is also an important requisite in postoperative care. Distention and vomiting may occur, requiring gastric lavage or continuous duodenal suction by Wagensteen's method. The restoration and maintenance of normal levels of body fluids is a question of knowledge of the normal, and how to correct dehydration and the loss of sodium chloride and other important electrolytes. At the same time glucose must be supplied to afford caloric requirements until tolerance of the gastrointestinal tract has been reëstablished.

Tympanites and serious ileus are prevented by the use of pitressin, as advocated by Potter, but the effect of this drug upon distention already present is less marked and is generally transient. During a stormy and prolonged convalescence, vitamin deficiencies must be combated. The work of Harvey and his co-workers on wound disruption due to vitamin deficiency is particularly applicable to cases in which disruption would be of such serious consequence. Blood transfusion is a valuable supportive measure.

Sequelae. Recurrence of the hernia is not an infrequent sequel to an operation for strangulation. This may be due to the severity of the operation, to unavoidable damage to the tissues during attempts at reduction, and to the fact that in some instances the constricting band or ring may have to be divided. In inguinal or femoral hernia, damage to Poupart's ligament is a predisposing cause of recurrence. The patient's condition may enforce a speedy and less anatomic closure. Sometimes contamination of the sac by organisms transuded from the imprisoned loop will result in wound infection (the influence of the latter upon the recurrence-rate is well recognized).

Late stenosis causing an incomplete or chronic intestinal obstruction may be the ultimate fate of a loop of bowel which seemed somewhat questionable at the time of operation and was consequently returned to the abdomen. Garré (1892) and Maass (1895) first reported such cases. The latter explained the stricture formation as a result of necrosis of the mucosa; in this condition the stenosed area is found to be lined with atrophic and smooth mucous membrane.

Where only a very limited amount of intestine is involved, a tight stricture may be caused, the area being hard, pale, fibrous and lacking all semblance of intestine. Here, the bowel proximal to the stricture may become hypertrophied as well as dilated while distally it is collapsed.

Schmieden and Scheele ascribe the occurrence of this type of stricture, which is annular and slowly progressive, to thrombosis of the arteriole in the mesentery supplying that area of the intestine. Eising reports two such cases.

CONCLUSIONS

1. Strangulated hernia constitutes one of the most urgent of surgical emergencies.

Time is of the greatest importance, for the earlier the operation is performed the greater prospect there is of survival.

2. Taxis is generally unsafe and therefore to be condemned.

3. The diagnosis is not difficult if a careful examination is made of the sites of abdominal hernia in every case of suspected "acute abdomen."

4. Treatment consists of gentle release of the imprisoned contents and careful repair of the hernia.

5. Resection is advisable unless the viability of the involved intestinal loop seems definitely assured. When in doubt, it is wiser to resect.

6. If, during the operation, the imprisoned loop slips back before it has been thoroughly inspected, it should be exposed and its viability definitely ascertained even if a laparotomy is required in order to gain access to it.

7. Attention must be paid to restoration of fluids, chlorides and glucose by venoclysis during the immediate postoperative period.

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RUPTURE OF THE BLADDER AND ACUTE RETENTION OF URINE*

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RUPTURE OF THE BLADDER

RUPTURE of the urinary bladder is relatively infrequent, largely due to the fact that this viscus is carefully and securely placed in the depths of the bony pelvis where it is inaccessible to trauma except for the most severe crushing injuries to the pelvis or trauma associated with more or less extensive distention of the bladder.

This series of cases is from the Urological Department of the City of Detroit Receiving Hospital for the three year period ending May 31, 1939.

The infrequency of this injury is shown by the fact that for the period above mentioned there were in three Detroit hospitals with 137,661 admissions only eleven cases.

1. City of Detroit Receiving Hospital with 63,154 admissions, had ten cases of rupture of the urinary bladder.

2. Harper Hospital with 53,137 admissions, reported one case of rupture of the urinary bladder.

3. Children's Hospital of Michigan with 21,370, reported no cases of ruptured bladder.

Dr. Francis W. Hagner, in the first edition of Cabot's "Urology," quotes at length regarding the frequency of rupture of the urinary bladder, bringing the literature down to 1918.[1–4]

The writers he cites call particular attention to alcoholism as the contributing factor and all show a terrific mortality. Later, Keane[5] reported a series of cases showing a mortality similar to that noted by earlier reporters. Three of his cases were gunshot injuries with complicating multiple intestinal perforations. Six did not come to surgery until twenty-four or more hours after injury. All observers have noted that the mortality rate mounts with the hours of delay following injury. The points to be noted are the rather low social status of the individuals and the intoxication present. These observations are borne out in our experience. In the series of ten cases at the Detroit Receiving Hospital seven of the individuals were alcoholic and had been drinking recently, thus having more or less distended bladders at the time of the injury.

The symptomatology is sometimes varied and indefinite but frequently a tentative diagnosis can be made from the history and the clinical findings confirmed by: (1) catheterization with injection of small amounts of saline solution which cannot be recovered; (2) cystography—intravenous urography; (3) cystoscopy.

All these patients had a more or less acute retention of urine, either complete or a slight dribbling of a few drops of bloody urine. The symptoms depend in large part on the time element involved. In early cases there is shock, with urinary retention, low abdominal tenderness and fulness. Late cases may present the picture of peritonitis.

Catheterization may show a small amount of very bloody urine or a large amount of blood-stained fluid, the latter if the

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catheter passes through the laceration into the abdominal cavity.

Cystography or intravenous urography

Fig. 1. Male, age 40. Spontaneous rupture following vigorous attempt to void after a "beer party." The man stated that after severe and prolonged straining in efforts to void he suddenly had the sensation of something giving way in his abdomen. Operation thirty-six hours after rupture, with suture of laceration and suprapubic drainage and peritoneal drainings because of intraperitoneal abscess. Recovery. Note tip of catheter in the abdomen.

show extravasation of the contrast medium either into the abdomen or laterally along the abdominal wall, depending on whether the laceration is intra- or extraperitoneal.

Cystoscopy may show the tear in the bladder wall or may be absolutely valueless owing to inability to distend the bladder or to the fact that the beak of the cystoscope may be lost among the coils of the intestines.

The diagnosis in most of these cases was established by the house staff before the patients were seen by the attending staff. In most of the cases of this series, cystograms were made which either made or confirmed the tentative diagnosis of rupture of the bladder. Sodium iodide (15% solution) was used as the contrast medium. Air may also be used.[6] We have found that cystograms apparently do no damage whatsoever as all but two of our patients made satisfactory recoveries. In the two fatal cases there were, in addition to ruptured bladder, multiple fractures including severe skull fractures. In one case

Fig. 2. Female, age 3. Struck by automobile. Fractured pelvis, sacrum and femur. Extraperitoneal rupture and extravasation of urine and blood into pre- and perivesical spaces. Suprapubic cystotomy and drainage of perivesical area. Recovery.

the diagnosis was made without cystogram and in the other with the aid of cystogram.

Cystoscopy may be of value and was diagnostic in one of the series. However, I feel that one should not add the trauma of cystoscopy to the shock already present until all less rigorous procedures have been exhausted.

Treatment in these cases has been surgical—open operation—as soon as the patient has sufficiently recovered from shock to permit operation. Some of these patients have been so severely shocked that several hours elapsed before operation could be undertaken. The shock is combated by the usual methods of heat, morphine, blood transfusion, intravenous glucose and saline.

A low midline incision is made and the muscles separated. The entire pre- and perivesical area is usually found to be infiltrated with blood, which obliterates landmarks. The bladder is generally collapsed and in an attempt to pick up the bladder wall with Allis forceps the peritoneum may be opened. This is of no

moment as it should later be opened for inspection in any event to determine the presence of intra-abdominal injury. The laceration is located and closed transvesically or, if this is difficult, the closure may be made from the peritoneal side. Both procedures are equally satisfactory.

In some of these cases it was felt that peritoneal drainage was necessary because of the length of time before operative interference, and in one case because of rather extensive infection from the extravasation of urine into the abdominal cavity. All patients had suprapubic drainage for a week or ten days, following which a urethral catheter was substituted and the suprapubic sinus closed.

Briefly reviewing this series of cases (Figs. 1–3), it will be noted that:

1. Seven of the ten were alcoholic.
2. Diagnosis was made with the aid of cystograms in seven of the cases.
3. Cystogram seems to have no injurious effect or interrupt the recovery in any way.
4. There were two deaths, both in individuals with multiple fractures, including skull fractures.
5. The age incidence, with one exception, was in the third, fourth, and fifth decades.
6. Operation was done from four hours to six days after injury. Contrary to all accepted precept, the individual operated on six days following the rupture made a rather uninterrupted recovery.
7. In one case a gunshot injury had caused two small pellets to lodge in the bladder. These were removed cystoscopically. The other patients were dealt with by open operation.
8. Two of the cases were extraperitoneal ruptures; seven were intraperitoneal ruptures.
9. One case occurred in another hospital. This was an industrial accident and in addition to the rupture of the bladder there was rupture of the urethra, multiple fractures of the pelvis and other injuries resulting in death. (Seen with Dr. A. C. Hall.)

CONCLUSIONS

1. Rupture of the urinary bladder is uncommon.
2. Early diagnosis is essential to proper treatment and satisfactory result.
3. A preoperative diagnosis can usually be made.
4. Uncomplicated ruptured urinary bladder seen early and dealt with surgically early, does not carry the high mortality mentioned by earlier writers.

ACUTE RETENTION OF URINE

Acute retention of urine may be met with in and is frequently due to:

1. Acute infections—general sepsis, typhoid fever, pneumonia, etc.
2. Ante- and postpartum urinary tract infection.
3. Spinal cord lesions (lues, tumor, meningitis, poliomyelitis, trauma).
4. Vesical neck obstruction—adenoma and carcinoma of the prostate—fibrosis of the bladder neck.
5. Urethral stricture—inflammatory or traumatic.
6. Rupture of the urethra:
   - A. Pendulous.
   - B. Bulbomembranous; anterior to urogenital triangle, varying with laceration to complete severance associated with the fracture of the pelvis.

As the subject of this symposium is Emergency Surgery, it has seemed advisable to eliminate such cases as are amenable to management with the soft rubber catheter and limit the scope of the discussion to such cases as require immediate surgical intervention either with special urethral instruments or with open operation, such as perineal section or suprapubic cystotomy.

The acute infections and urinary infection in pregnancy and the puerperium may therefore be eliminated except where organic lesions of the urethra prevent the passage of an ordinary soft rubber catheter.

Spinal cord lesions, in the absence of organic lesions of the urethra or bladder neck such as stricture or prostatic obstruction or obstruction due to acute trauma, may also be eliminated from the discussion as ample time is provided for study of methods of dealing with this type of case (attempts to produce an automatic bladder, suprapubic cystomomy or inlying catheter[7,8,9]). The management of this type of case is highly controversial and is a chapter by itself.

FIG. 3. Female, age 34. Kicked in abdomen in drunken brawl. Suprapubic cystotomy. Suture of laceration. Drainage of peritoneal cavity. Recovery. Note extravasation across lower abdomen extending well up to the right.

Vesical neck obstruction in which no type of catheter can be introduced into the bladder leaves no choice but a suprapubic cystomony or a suprapubic stab with a trocar and introduction of a drainage tube after the method of Lower.

All attempts to catheterize these old and often greatly debilitated prostatics should be made with the utmost gentleness. A metal catheter may easily produce a false passage through the obstructing prostate with resulting hemorrhage, infection and pelvic cellulitis, and for this reason is considered a very dangerous instrument and should rarely, if ever, be resorted to. A suprapubic cystotomy is much less shocking and dangerous to the prostatic, without the risk of "poking holes" in the prostatic urethra.

FIG. 4. Type of pelvic fracture producing varying degrees of laceration of prostatic urethra with extraperitoneal extravasation of urine and hematoma, as shown in Figures 5 and 6. The displaced fragment produces a shearing or tearing (partial or complete) of the prostatic urethra. Figures 2 and 6 are cystograms in cases of extraperitoneal rupture of the bladder but show the urinary extravasation and hematoma found in rupture of the prostatic urethra. A urethral catheter drained blood and urine. At operation the tip of the catheter passed out through the laceration in the prostatic urethra. Seen with Dr. J. A. Smith.

Impassable stricture of the urethra may be either inflammatory or traumatic. Here again, the utmost gentleness is necessary. Filiform bougies and followers may be tried. If there is some dribbling of urine and *no evidence of urinary extravasation*, attempts to pass an instrument through the stricture may be repeated before resorting to surgery. If one is fortunate enough to pass a filiform bougie through the stricture it should be tied in, regardless of how tight it may seem to be. Regardless of the snug fit in the stricture, the patient will be able to urinate around the bougie. The stricture may be so tight that the smallest follower cannot be passed through it. However, after twenty-four to forty-eight hours, a small follower may frequently be attached to the filiform and passed without difficulty

During the past four or five years at the City of Detroit Receiving Hospital there has been only an occasional external urethrotomy for stricture. Most so-called "impassable" strictures have been sufficiently relaxed under spinal anesthesia (general anesthesia apparently does not produce relaxation). Practically all of the strictures have been dealt with by dilatation without urethrotomy. On my own service in the last five years, we have not had more than a half a dozen external urethrotomies for stricture and in all of these there were complicating perineal sinuses. The remainder of the cases were dealt with by dilatation.

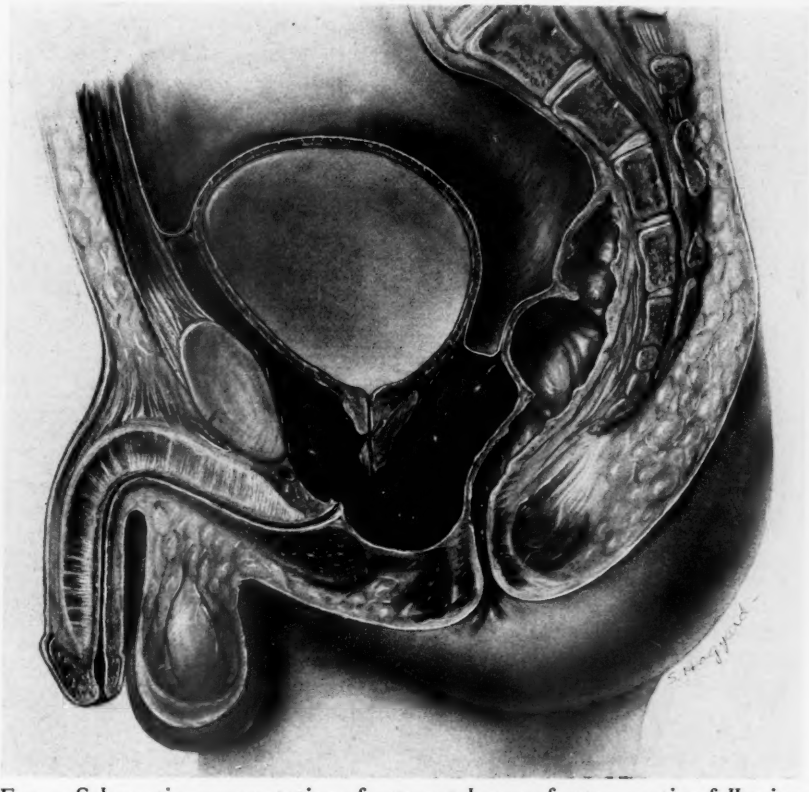

Fig. 5. Schematic representation of extreme degree of extravasation following rupture of urethra posterior to triangular ligament. Shows why inlying catheter may drain urine but still not drain the bladder and demonstrates the necessity of suprapubic cystotomy. Also shows necessity of perineal drainage.

In case the stricture cannot be managed by dilatation, a suprapubic cystotomy can always be done. Drainage for a week or ten days quite frequently relieves the edema and swelling in the stricture sufficiently to permit a filiform to be passed and subsequent dilatation carried out. If the stricture is still impassable an external urethrotomy may be done. This (external urethrotomy without a guide) should be attempted only by one experienced in perineal surgery.

In connection with the treatment of acute retention of urine due to impassable stricture of the urethra, the problem of extravasation of urine must be considered. This type of case is rarely seen in private practice but is almost invariably observed in the large municipal hospitals. Most of them occur in broken-down, debilitated patients who are bad surgical risks from the beginning.

At first sight, suprapubic cystotomy with a diversion of the urinary stream would seem very inviting, but all too frequently the extravasation and infection have extended up to the abdomen, so that in doing a suprapubic cystotomy one must go

through an infected area into the prevesical space with its extensive blood supply. Thus infection is almost deliberately carried into the prevesical space, often leading to general sepsis and death. Wide multiple incisions through the area of extravasation with excision of necrotic tissue should be carried out. Either a catheter is passed through the rupture in the urethra behind the stricture on into the bladder for drainage, or the patient is permitted to urinate through the ruptured urethra into the dressings. The mortality in this type of case is high, due in part to the debilitated condition of the patient and in part to the extent of the infection.

Fig. 6. Female, age 50. Extraperitoneal rupture of bladder with extensive extravasation of urine following low abdominal trauma. This shows type of extravasation in extreme degree met with in rupture of urethra posterior to triangular ligament. This case was in a female and shows the anteroposterior view of the extravasation seen in ruptured urethra in the male shown schematically in Figure 5. In the male with rupture of the prostatic urethra, the extravasation and hematoma are much deeper in the pelvis and may require dependent drainage through the perineum. Note in Figure 5 the ease with which perineal drainage of the cavity can be carried out. Also, it shows the applicability of drawing the proximal and distal portions of the urethra together with a pilcher or Hagner bag after the method of Ormand and Cothran.[16]

A rupture of the pendulous portion of the urethra is rare, seen only in the severest type of crushing or grinding injury involving the penis or in cases of trauma to the erect organ as in drunken debauches, etc.

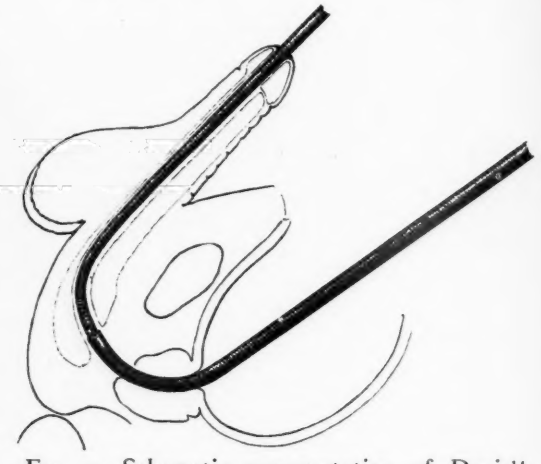

Fig. 7. Schematic representation of Davis[14] procedure of passing a sound through a ruptured urethra. If Davis instruments with male and female tips are not at hand, ordinary urethral sounds may be used.

Herman[10] calls the attention to a case of a fracture of the pendulous portion of the urethra and notes that this type of rupture usually is the result of direct trauma of the organ against the female pelvis. A similar but less complicated case came to the writer's attention some years ago, acquired as described by Herman, in which there had been a fracture of the erect penis with considerable bleeding. The patient came under observation some years after the injury and there was a marked stricture of the pendulous urethra which did not respond well to dilatation.

In this type of case, probably the best procedure is to pass, or attempt to pass, a soft rubber catheter through the lacerated portion of the urethra into the bladder to maintain drainage and at the same time splint the urethra, maintaining patency until healing has taken place. If this measure is unsuccessful a suprapubic cystotomy should be done.

Rupture of the bulbomembranous portion of the urethra is due almost invariably to "straddle" injuries, kicks, or other direct trauma to the perineum. This type of injury is seen in a lad who is walking a fence and falls astride; also in industrial workers,

sailors, or riggers who fall astride a beam or some such object or in an individual stepping on a loose "manhole" cover, as described by O'Connor.[13] Aside from the immediate shock accompanying the injury, usually there is bleeding from the urethra together with acute urinary retention. In late cases there may be extravasation of urine into the penile and scrotal tissues.

Attempts to pass various types of urethral instruments are usually unsuccessful and such being the case, unless one is adept in perineal surgery, an immediate cystotomy should be carried out. Even then it is a debatable point whether to attempt an immediate repair of the contused and lacerated urethra or to drain the hematoma and carry out the repair a few days later, applying the procedures described by Cabot[11] and MacGowan.[12] After opening the bladder an attempt may be made to maneuver an instrument through the lacerated urethra after the method described by Davis.[14] (Fig. 7.) A sound is introduced through the urethra to the point of laceration and a second sound through the cystotomy wound and then through the posterior urethra until the two meet. The anterior sound will follow the posterior sound into the bladder, after which a catheter may be attached to the beak of the anterior sound and drawn through the urethra and anchored, furnishing an internal splint for the urethra.

These patients should not be dismissed until they are thoroughly impressed with the fact that for the rest of their lives they are somebody's patient. According to the dictum of Keyes, they should report to their urologist for dilatation on New Year's Day and the Fourth of July.

Rupture of the prostatic urethra is a complication of fracture of the pelvis and occurs through the bladder neck, through the prostatic urethra or at the apex of the prostate, and is due to a shearing or tearing through the urethra by the displaced fragments of bone. (Fig. 4.) Spicules of bone may also penetrate the bladder. This laceration takes place behind the triangular ligament and extravasation of blood and urine is pre- and perivesical. These patients come to the hospital in more or less shock, unable to void, with some bleeding from the urethra, and marked fulness and tenderness over the suprapubic area. Usually there is a "doughy" feel in the suprapubic region. Attempts to catheterize are usually unsuccessful but occasionally a catheter will pass and withdraw bloody urine. This may be due to the fact that the catheter passes out through the laceration of the urethra into a hematoma or an area of extravasation of urine in the pre- or perivesical space. Figures 2, 4 and 6 show pre- and perivesical extravasation of blood and urine.

In view of these findings there is no choice other than immediate suprapubic cystotomy with evacuation of any hematoma and drainage of the perivesical area. The area of extravasation may be so deep in the pelvis that adequate drainage can be attained only through the perineum. With the bladder opened, procedures for maintenance of the continuity of the urethra may be carried out.

The laceration of the urethra may vary from a tear to complete severence. (Fig. 5.) Here again the procedure of Davis[14] may "turn the trick" or in the instance of complete severence the procedure devised by Ormand and Cothran[16] of attaching a Hagner or Pilcher bag to the urethral sound and drawing the tube through the urethra as in the introduction of the bag in prostatectomy, will draw the proximal and distal ends of the urethra together. Young[15] reports a series of cases in which repair was carried out by the perineal route.

It is important to note that in a large percentage of these cases injury involving the prostatic urethra causes impotence, probably due to damage to the blood or nerve supply, and perhaps partially to nerve damage of or interference with the blood supply of the penis. This factor of impotence is a matter of importance from a medicolegal standpoint and from the standpoint of responsibility for subsequent

neuropsychiatric disturbances. Both the patient and the employer should be informed that the patient is to be under somebody's care indefinitely and must have periodic dilatation of the urethra to maintain patency and prevent subsequent stricture formation. Considerable stress has been placed on this necessity for prolonged observation where the bulbous and prostatic urethra is involved, as the writer's cases of this type have been industrial accidents subject to the workmen's compensation laws. Some of these patients refused to follow instructions and a few years later appeared with complications which caused the employers great annoyance and expense.

CONCLUSIONS

1. Urinary retention due to impassable stricture and urethral trauma demands immediate intervention.

2. Over-enthusiastic instrumentation may produce varying degrees of trauma with hemorrhage and sepsis.

3. Delay may lead to urinary extravasation.

4. These cases must report at regular intervals for urethral dilatation in order to prevent recurrence of the stricture.

5. The most important *dont's* appear to be:

A. Do not over-instrument an already damaged urethra.

B. Do not delay surgical intervention.

In connection with delay, William J. Mayo[17] writing editorially on perforation of an abdominal viscus, says "the risk of immediate operation may be relatively small and responsibility must rest on those who caused delay," and quotes John B. Murphy as saying, that one must "get in quick and get out quicker." These sayings are most applicable in the management of ruptured bladders and acute urinary retention.

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ECTOPIC PREGNANCY*

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ECTOPIC pregnancy whether recognized before, during, or after the act of rupture always demands prompt surgical intervention. Associated with the three anatomic types indicated are different signs and symptoms, and each of the resulting clinical groups should be discussed separately. This plan simplifies comment upon the task, difficult at times, of accurate differential diagnosis, a cardinal requirement of competent treatment.

DIAGNOSIS

It is almost impossible to differentiate a case belonging to the first group, before rupture, from an early uterine pregnancy. A sausage-shaped, unilateral mass in the position of a tube suggests the correct diagnosis, but many an over-enthusiastic surgeon has found, at operation, a normal pregnancy with a large corpus luteum at the tip of an elongated ovary. Howard Kelly used to tell of having seen Dr. B. C. Hirst, an exceptionally qualified gynecologist, carefully inspect both tubes at a pelvic operation, and then have one rupture three weeks later!

Definition in the second group rarely, if ever, proves difficult. A former teacher of mine was fond of repeating his belief that the policeman on the beat could diagnose accurately a ruptured tubal pregnancy. The classical picture is that of a young woman, usually with a history of amenorrhea, stricken suddenly with abdominal pain, collapse, and more or less vaginal bleeding. Oftentimes in this group abdominal pain radiates to one or both shoulders, indicating intraperitoneal hemorrhage.

With respect to management this group does not follow the surgical rule, that shock whenever present must be treated before operation. Here, shock is apt to progress steadily until the hemorrhage has been controlled; therefore, immediate laparotomy becomes advisable. The patient, if at home, should be given morphia in adequate dosage to relieve anxiety and pain, and removed at once to a hospital, preferably on a stretcher.

Most surgeons feel that the intravenous administration of fluids is contraindicated until after bleeding has been controlled, as treatment which raises blood pressure tends to increase hemorrhage. However, exceptions occur to every rule, and we have all seen cases in which preoperative blood transfusion, intravenous glucose in saline, or gum acacia solution, has unquestionably saved a life. Depending on the degree of circulatory failure, the transfusion will be given just before, during or after the laparotomy; but never given until the surgeon is ready to operate.

In this group the extent of the operation should be limited to the control of bleeding, which requires, of course, adequate removal of all pathologic tissue. For example, one of the patients in our series, in shock, was operated upon for right tubal rupture. Right salpingectomy was performed, without removing a cornual wedge. Eighteen months later she returned for consultation, having missed two periods, was admitted to the hospital and discharged after five days with a diagnosis of intrauterine pregnancy. Four months later on account of low back pain she came to the out-patient *x*-ray department. There she suddenly collapsed and was rushed to surgery, where a ruptured right interstitial pregnancy was found in the portion of the tube left at former operation. Such accidents, however, do not challenge the truth that the margin

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of operative safety is narrow in the presence of shock; unnecessary procedures then become hazardous. The death of a patient in our series occurred at the outset of the operation, just as the peritoneum was opened.

In the third group, the chronic stage of tubal pregnancy, diagnosis becomes difficult. The differentiation here includes unilateral ovarian cysts, fibroids, unilateral inflammatory masses, pregnancy, retained secundines, and appendicitis. Probably accurate diagnoses are made in no more than a third of these cases. After studying such problems as they often present we may have to content ourselves with the remark that "tubal pregnancy must be considered." If it is found, do we hesitate to take credit for a correct diagnosis? Not often. On the other hand, many of these bold assertions are hidden away in the histories of patients who actually turned out to have suffered from one of the other possible disturbances mentioned above.

Among the cases included in this report shock was present in eighty-one instances at the time of operation. Sixty-three of these patients were operated upon immediately after admission; the remaining eighteen had been in the hospital for a varying length of time, with the diagnosis in doubt, and the situation became clear only when shock developed. Certainly these patients were favored by being in the hospital at the time, but delay in diagnosis appreciably increased the surgical risk involved.

To evaluate various diagnostic points, we have studied the histories of the ectopic pregnancies operated upon at the Los Angeles General Hospital between 1932 and 1937, a series of 319 cases. Fourteen of the women had successive tubals; and these "repeats" have been included, as they presented a different clinical picture in each of their two experiences.

DEATHS

A short summary of the fatal cases is pertinent.

CLINICAL DATA FROM 319 ECTOPIC PREGNANCIES

Age			
Below 20 Yrs.	20–30 Yrs.	30–40 Yrs.	40 Yrs. and Over
13	164	115	13

Parity			
Nullipara	1–4 Pregnancies	5 Pregnancies or More	Not Stated
60	194	45	20

White Blood Count			
8,000 or Less	8 to 12,000	12,000 to 20,000	20,000 and Over
64	71	101	48

Red Blood Count	
Over 3,500,000	Under 3,500,000
119	159

Hemoglobin	
Over 70 Per Cent	Under 70 Per Cent
117	165

Sedimentation Time	
Over ½ Hour	Under ½ Hour
105	30

Blood Pressure	
Over 100	Under 100
188	99

Friedman Test	
Positive	Negative
41	20

Shock. 81. On Admission 63. After admission 18.

		Per Cent	
Irregular bleeding	204	61	
Amenorrhea	180	56	
Fainting	116	35	
Shoulder pain	74	23	
Painful defecation	27	9	
Attempted abortion	16		
Repeated admissions	20	6	
Appendectomies	28	9	(3 acute)
Deaths	5	1.5	
Peritoneoscopy	11		
Colpotomy	11		
Curettements before admission	7		
After admission	4		
Autotransfusions	122		
Tubal rupture right	81		
Left	80		
Tubal abortion right	59		
Left	59		
Unruptured tubal pregnancies	24		
Abdominal pregnancies	8		
Cornual pregnancies	5		
Interstitial pregnancies	3		

Preoperative Stay in Hospital		
2–7 Days	1–2 Weeks	Over 2 Weeks
53	25	28

Postoperative Stay in Hospital		
Less than 2 Weeks	2–3 Weeks	Over 3 Weeks
218	69	27

Case 1. Age 21, gravida 0. W.B.C. 8200, Polys 70 per cent. R.B.C. 3,300,000. Hgb. 70 per cent. B.P. 110/70. The period was three weeks overdue. A positive Friedman was reported five days after admission. Six days later the patient went into shock. Double salpingec-

tomy and left oöphorectomy were performed. Death occurred twelve hours later. Autopsy showed a bleeding vessel at the site of operation.

Case II. Age 37, gravida vii. W.B.C. 22,300. Polys 91 per cent. Sedimentation rate 13 minutes. R.B.C. 1,890,000. Hgb. 30 per cent. B.P. 130/80. The patient had missed two periods. Three days before admission she fainted three times. She was admitted to the medical ward, and after forty-eight hours was transferred for immediate operation. Left salpingectomy was done and death occurred on the seventh postoperative day from paralytic ileus.

Case III. Age 30, gravida v. W.B.C. 15,500. Polys 86 per cent. R.B.C. 3,460,000. Hgb. 75 per cent. B.P. 130/70. This patient had missed a period, and eight days before admission she had a sudden pain in the left lower quadrant and fainted. She had been bleeding slightly since. She fainted again on the day of admission. Operation was done under spinal anesthesia four hours after admission. Respirations ceased as the peritoneum was opened.

Case IV. Age 28, gravida v. W.B.C. 14,700. Sedimentation rate 30 minutes. R.B.C. 1,740,000. Hgb. 35 per cent. B.P. 92/55. The patient had had a scant period and had bled for three weeks. A diagnosis of tuberculous salpingitis with possible intrauterine pregnancy was made and operation was carried out twelve days after admission. A right unruptured tubal pregnancy was found. Hysterectomy and double salpingectomy were done. The patient died on the sixth postoperative day. Autopsy showed extensive pulmonary tuberculosis.

Case V. Age 30, gravida ii. W.B.C. 3,350. Sedimentation rate 12 minutes. R.B.C. 3,730,000. Polys 72 per cent. For one month the patient had had amenorrhea. She then began to bleed and kept up for a month until her admission. A catheter was used before admission. After pelvic examination the pulse went to 136, and the patient was in severe shock. She was rushed to the operating room, where a ruptured right interstitial pregnancy was found. Hysterectomy and right salpingectomy and oöphorectomy were done. Autotransfusion and 450 c.c. whole blood failed to help and the woman died three days later. Autopsy showed acute pulmonary edema.

CLINICAL STUDY

Farrar has concluded that the white count rises shortly after hemorrhage, and drops later. Most of our cases, having only one count, showed a slight increase in leucocytes. A slow sedimentation rate pointed to ectopic in distinction from pelvic inflammation. A low red count and low hemoglobin suggested hemorrhage.

The fact that there were twenty negatives out of sixty-one Friedman tests has great practical significance. This valuable test is not infallible, as a recent case of mine bears witness. The woman 32 years old had had light radium treatment for metrorrhagia six months before. Following the use of radium there were four months of amenorrhea; then bleeding resumed and gradually increased, until she was brought to a neighboring suburban hospital. During the week she remained there she was twice curetted and was given two blood transfusions, and her uterus was packed on two occasions. The day she was transferred to our hospital the Friedman test was reported positive. At operation we found engorged tubes and free pus in the cul-de-sac from which Streptococcus hemolyticus was cultured. On the seventeenth day after operation she died of streptococcic peritonitis.

Peritoneoscopy, a useful diagnostic measure, gave a correct diagnosis in ten out of eleven cases in which it was employed. The case erroneously reported as an ectopic showed massive hemorrhage from a ruptured follicle, and required an immediate laparotomy.

Colpotomy was used eleven times, with one mistake. In that instance a straw colored fluid drained out, a finding upon which we based a diagnosis of intraligamentary cyst. At operation, however, nine days later, an ectopic pregnancy was found.

In the differentiation of ectopic from threatened abortion or retained secundines, curettage may be very useful. If decidua without chorionic villi is obtained, the diagnosis of ectopic is justified. Unless fetal parts, or obvious retained placental fragments are recovered, the surgeon should await the microscopic report on

the tissue. In our series curettage was done only four times, and as it happened the information obtained was not helpful.

Our statistics emphasize the diagnostic importance of irregular bleeding, amenorrhea, fainting and shoulder pain. The incidence of painful defecation was only 9 per cent. Pain of some kind, to be sure, is ordinarily the reason why a woman with an ectopic pregnancy seeks professional advice. But the descriptions of pelvic pain in the histories I have reviewed were too vague to permit accurate classification. None the less, complaint of pain radiating to one shoulder or the other has appeared so often that its importance as a pathognomonic symptom must be stressed.

Autotransfusion was used in 122 cases, over a third of the series. When there is no evidence of infection, whatever free blood the peritoneal cavity contains should be citrated, strained, and returned to the patient through a vein in one of the extremities.

Ludwig reported a series of 145 ectopic pregnancies in which sixty-three appendectomies were done. Among our patients twenty-eight appendices were removed, twenty-five chronic and three acute, of which one was ruptured. The convalescence was not noticeably affected in any of these cases. It is noteworthy that an operation for a gangrenous appendix was performed on one patient two years after a salpingectomy for chronic tubal pregnancy. We do not advocate appendectomy routinely, but the appendix should always be inspected, and whenever it is pathologic it should be promptly removed.

SUMMARY

1. Ectopic pregnancy always merits prompt surgical treatment, and this becomes imperative in case of tubal rupture.

2. Intravenous medication will be wisely postponed until the preparations for operation have been made.

3. The Friedman test, negative in 33 per cent of the cases in this series, is much less reliable with ectopic than with uterine pregnancy.

4. A great many ectopic pregnancies show neither amenorrhea nor irregular uterine bleeding.

5. In the event of active bleeding, surgical procedures should be limited to control of hemorrhage with adequate removal of pathologic tissue.

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SALPINGITIS AND PELVIC CELLULITIS*

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A DISCUSSION of the inflammatory diseases of the female is found in the writings of the ancients. Dr. Howard A. Kelly[1] has said "The history of the treatment of pelvic abscess is frought with the deepest interest, for it exhibits in miniature all the phases of the growth of gynecology at large."

Due to lack of understanding of the pathology of pelvic infection, the earliest attempts in treatment were represented by extreme conservatism. Not until the early part of the nineteenth century was any attempt made to evacuate pus, when Récamier (1830–1840) practiced vaginal puncture and drainage. This was before the days of anesthesia, a decade before Marion Sims popularized the vaginal speculum, and thirty years before Lister applied to surgery the principles of Pasteur.

Récamier made few records, leaving to his pupil, Bourdon, the inspiration to carry on this simple and earliest operation for the treatment of pelvic infection. In 1886 Saroyenne advocated the use of a spear pointed trocar, dilatation of the drainage tract to admit two fingers, and the insertion of a two way rubber tube with daily irrigations of the abscess cavity

With the advent of abdominal surgery by Lawson Tait in 1880, an actual view and understanding of the lesion was obtained for the first tme, and there developed a period of radicalism, shocking to those who had practiced conservatism. By the year 1890, though a relatively high mortality accompanied this method, the abdominal route had been adopted in many clinics as the best way of treating most cases of inflammatory disease of the pelvis.

There followed in 1890–1891, a short period of ultra-radicalism, unscientific and extreme, in which vaginal panhysterectomy was advocated by Peon and Segond. In a condition clinically characteristic of large pelvic abscesses which might be mistaken for malignant tumors, hard, nodular and adherent, Peon performed vaginal panhysterectomy. When the uterus could not be removed in toto he dug it out piecemeal, controlling the bleeding by clamps left in place for forty-eight hours, irrigation being started on removal of the hemostats.

The method of Peon met with little favor; even Segond, his admirer, could not view the operation with complete approval. It was never widely accepted, and came gradually into limited use.

From 1890 to 1892 the opinion of groups or schools was divided as to which of the three methods was suitable: vaginal drainage, laparotomy with extirpation of the adnexa, or the vaginal hysterectomy of Peon with removal of the tubes and ovaries. There were strong advocates of each.

In September, 1892 the first International Congress of Gynecologists and Obstetricians met in Brussels. Representatives from practically all the European societies and from America were present. One of the chief subjects for discussion was the treatment of pelvic suppuration. The first paper was by Segond who advocated the operation of Peon, in all cases in which the lesion was bilateral. He admitted, however, that though the operation had greatly enriched the gynecologic repertoire, it should not be used exclusively. Peon, who was in the chair, supported his own work. Travers of London expressed the

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views of most British surgeons by urging laparotomy. Goullioud of Lyons spoke in favor of the method of his master, Laroyenne, saying, however, that he had been using more radical operations when drainage through the vagina had not been curative.

Each of these methods contributed to the knowledge of the subject. The outcome of the discussions was that the individual case called for a selected treatment, and Sanger of Leipzig put it aptly when he remarked that there were many roads that led to Rome.

Controversy continued, and American literature was replete with articles on operative procedure, containing, however, a scarcity of discussion on indications for operation. Henrotin of Chicago defended vaginal drainage, and condemned radical procedures. Joseph Price of Philadelphia, Franklin Martin of Chicago and Howard A. Kelly of Baltimore, pioneers in abdominal surgery and gynecology, advised salpingectomy. These men were the outstanding contributors who added largely to the clarification of pelvic infection.

Today with a better understanding of the nature and pathology of pelvic disease, treatment is again conservative. Gynecologists are agreed that almost without exception the acute infections are to be left strictly alone.

The most frequent source of pelvic infection is gonorrhea. According to Curtis,[5] the gonococcus is the responsible organism in from 70 to 80 per cent of all cases of salpingitis, the tubercle bacillus in 5 per cent, followed by the streptococcus, staphylococcus, and colon bacillus. Puerperal sepsis accounts largely for the presence of these latter organisms. Intra-abdominal lesions, not mentioned by Curtis, play a part. Graves[7] wrote years ago that tubal infection following appendicitis had not been sufficiently emphasized. Rubin[13] has called attention to the number of cases of sterility due to closure of the tubes from this cause.

Rarely does an infection of the tubes follow immediately a primary gonorrheal urethritis or endocervicitis. Invasion may result from instrumentation and improper treatment, or at any time during menstruation when the cervix is soft and the canal open, suitable media being offered by menstrual blood. Invasion beyond the internal os is rare in children or in women past the menopause since menstruation does not occur. Rubin, as quoted by Curtis,[5] has shown that women who menstruate at infrequent intervals show a lessened incidence of tubal infection.

Often months or years intervene between the initial infection and tubal involvement when, either from reinfection or from awakening of a chronic infection, the tubes become involved.

There has been much discussion as to why gonorrheal salpingitis undergoes complete recovery in some cases, while in others it becomes chronic, although exacerbations may be frequent. Curtis[6] in 1921 undertook a study of this problem, using inflamed tubes which he ground and cultured. He reported as positive only nineteen in 192 cases and believed that the micro-organisms were rapidly killed by means of a bacteriolytic process, and were rarely recoverable later than two weeks after the disappearance of fever and leucocytosis. Curtis' work has been extensively quoted. Studdiford[14] writes that the only dissenting opinion has been by Wagner, who in 1925 stated that in his opinion "the repeated flare-ups which are typical of gonorrheal salpingitis suggest that the organisms do not entirely disappear from the pyosalpinx even though they cannot be demonstrated in culture."

Taking cultures from tubes and ovaries, Studdiford, by means of improved culture methods, found that in twenty-four patients suffering from salpingitis 66.6 per cent harbored gonococci in spite of the fact that in none of them was the disease in the acute stage. In one patient it seemed likely that the most recent infection was ten years previous. Nineteen were regarded

as subacute and from them thirteen positive cultures were obtained. Two were classified as acute exacerbations of chronic salpingitis, and both gave positive cultures. Three were called chronic or healed and one of these gave a positive culture.

Studdiford's important contribution necessitates a revision of previously accepted ideas regarding reinfection as compared with recurrent salpingitis.

Originally both tubes are always infected. One may heal completely or one or both proceed to further destructive changes. At first a simple endosalpingitis, as the disease progresses, it becomes more purulent in type; the tubes lose their cilia and the rugae become ulcerated and glued together. The walls are thick, with involvement of the muscularis and subserosa. Due probably to retraction and agglutination, the ostia become closed with concomitant closure of the tubal isthmus, and a pus sac is formed which may reach considerable proportions. Because of its weight, the tube, bent on itself, gravitates usually to the posterior leaf of the broad ligament: it may, however, adhere to the large intestine, abdominal wall, or bladder. There is an associated inflammation of the pelvic peritoneum, of the external lining of the ovaries, and of the subperitoneal cellular tissue, especially that between the leaves of the broad ligament.

Attachment of the fimbria to the ovary is another means of tubal closure. Because the dense albuginea is resistant to invasion, the ovary escapes with only a superficial infection. With the rupture of an underlying corpus luteum, however. infection enters the substance with destruction of a considerable part of its tissue. As the abscess grows the sac composed of tubal wall and stretched out ovarian tissue gives rise to a tubo-ovarian abscess. Though both ovaries are extensively involved and permanently damaged, mensturation continues.

It was formerly thought that a hydrosalpinx represented the end result of a tubal abscess, and that the enclosed pus had become gradually converted into a clear fluid. As quoted by Graves,[7] Menge first pointed out and Norris believes that a hydrosalpinx results from a mild inflammation which closes both ends and allows the collection of a serous fluid within the tubal lumen. Other causes are an inflammatory process arising outside the tube, a perisalpingitis from appendicitis, tuberculosis, or puerperal infection, and pelvic tumors, especially myomata.

Infection of the isthmus of the tube with the formation of palpable nodules, gonorrheal isthmica nodosa, is a form of salpingitis often overlooked at operation. Surgeons frequently amputate the tube, leaving the interstitial portion. This would be removed by a wedge-shaped piece of tissue in the cornua. Leaving the isthmic portion may give rise to continued infection, abscess, or even endometriosis. Nodules in this area are occasionally seen in tuberculous salpingitis.

All cases of gonorrheal salpingitis are accompanied by a certain degree of pelvic peritonitis which in rare instances, more commonly in children, may become general. With destruction of peritoneal epithelium and consequent gluing together of contiguous surfaces, the adhesions formed are at first light and easily separated. In the course of time they become firm and unyielding. They are seldom as dense, however, as those from a tuberculosis or streptococcic infection.

The treatment of pelvic inflammatory disease varies, depending on whether the disease is encountered in the acute or chronic phase. In acute cases there is a marked tendency for spontaneous remission of symptoms and pelvic findings, and operative treatment is not necessary. Therapeutic adjuncts have been sought which would hasten this resolution, such as, foreign protein injections, local heat therapy, fever therapy, and bactericidal drugs.

Foreign protein injections have been used on the basis that they promote antibody formation as well as give a febrile

reaction which has a bactericidal effect on the causative gonococci organisms. It is a clinical observation that frequently the most severe types of acute salpingitis show the greatest subsequent restoration of the pelvic organs to normal. Since these acute cases are accompanied by high fever, it has been argued that in the relatively afebrile case foreign protein stimulation is of benefit. The results are difficult to judge because of the natural tendency of the acute stage of the disease to regress, and the impossibility of differentiating between exacerbations and reinfections in the future. Also foreign protein therapy is usually combined with other forms of treatment such as bed rest and local heat. The most convenient forms of therapy consist of intramuscular (hip) injections of boiled skimmed milk and intravenous injections of typhoid vaccine. Commercial foreign protein preparations are available but are more expensive. An occasional patient will be found allergic to milk; and as a precaution against violent reactions from the typhoid vaccine administration, this foreign protein should only be given when the patient has been hospitalized. Nonspecific protein therapy is not devoid of danger as has been emphasized by Hektoen,[9] and by Bernstein and Ginsberg.[2]

Similarly, local applications of heat have been used in conservative therapy. Elliott treatments which consist of running heated water through a distensible rubber bag inserted intravaginally have been extensively used. Local heat applied to the vagina is not conducted more than a few millimeters beyond the mucosal surface, but does increase the blood supply to a greater depth and also sooth the pain, probably acting as a counterirritant. This treatment is entirely nonspecific, the heat being insufficient to kill the gonococci, but the treated patients note alleviation of pain and it has been a clinical observation that there is a more rapid resolution of the adnexal masses. Elliott treatments require careful supervision over the heat control mechanism. The bag filled with water at 110°F. is distended to one or two pounds pressure and the temperature raised gradually to 130°F. The degree of distention of the bag is quite as important as the degree of local heat—some patients cannot tolerate adequate distention of the bag. Burns of the vaginal mucosa have been noted. The Elliott treatments should not be given when the vaginal discharge is copious as in early postpartum cases or at the time of menstruation. Occasionally in acute cases of pelvic cellulitis, such as those found postpartum, or postabortal, and accompanied by a considerable degree of fever, the Elliott therapy acts as an irritant, causing pain and more fever. Elliott therapy is best used after the acute stage is over.

Fever therapy, using the heat cabinet, is a form of treatment in which cures up to 80 per cent or higher are reported. Under the able direction of Dr. Franklin Ebaugh of the Colorado Psychopathic Hospital, there were treated from the Gynecological Service nine cases of pelvic abscess. In all but one patient who had us discontinue the treatment because she could not tolerate it, the mass completely disappeared or was quickly reduced in size. Symptoms and fever responded promptly. In one case, an intra-abdominal mass, a mixed infection of several weeks' duration with loops of intestine and brawny induration of the abdominal wall and underlying viscera, was opened twice. No pockets of pus were encountered. Under fever treatment, drainage stopped, the wound closed, and the patient remained well. Of twenty-nine cases of acute salpingitis, all responded well as regards symptoms, pain, and fever. Four showed positive smears immediately following treatment, nineteen were negative, of six there is no report.

In spite of good results, heat treatment should not be recommended without careful consideration as it is not without danger. Apprehension, restlessness, confusion, delirium, convulsions, calcium tetany, and drop in blood pressure, as well as a severe neuritis later are complications.

It is so disagreeable that many patients object to a second treatment. Most careful and skilled management is necessary.

It is now universally accepted that gonorrhea responds to sulfanilamide therapy. Pain and fever disappear within a few days, the discharge decreases, pelvic masses become smaller or completely disappear within ten to fourteen days. Complications are rarely seen. The drug has a definite effect in the control of acute and subacute salpingitis. Long and Bliss[11] observed seven cases of gonococcal peritonitis treated without surgical intervention, all of which did well under large doses of sulfanilamide.

There is no universal agreement as to the amount of dosage, but to maintain a certain blood concentration sulfanilamide should be administered at four hour intervals. Four to 5 gm. per day for the first week and then about 3 gm. a day for two weeks are suggested, maintaining a blood level of 5 to 7 mg. per cent during the treatment. Others suggest lower doses, 40 gr. of neoprontosil, which is less toxic, though not so powerful as sulfanilamide. Bicarbonate of soda is given in conjunction and nicotinic acid will lessen the toxic effects of sulfanilamide-containing drugs.

It has been the experience of all who have used sulfanilamide in gonorrheal salpingitis that pain, fever, and masses disappear; the gonococcus can, however, in many instances be recovered from the cervix, urethra, Skene's or Bartholin's glands after the treatment is stopped. It is obvious that individuals free from discharge, who believe themselves cured, are asymptomatic carriers and have the potentialities of a great social menace. This would apply to other forms of treatment as well, but sulfanilamide, because of its lethal properties toward the gonococci offers a better chance of cure than other methods of treatment.

Pronouncement of a cure in women is more difficult than in men. Frequent examinations, made preferably immediately after or during menstruation, are necessary. Jones[10] noted that following treatment with sulfanilamide there are marked changes in the morphology and staining properties of the gonococcal organism. One should remember also that culture studies are much more reliable than those from microscopic smears.

Carpenter with co-workers[3] has shown that with cultures from the lower genital tract in suspected cases the incidence of proved gonorrheal infection has been raised almost 200 per cent. They use a technique of inoculation of a specially prepared blood agar plate incubating at 34°C. and 37°C. in an atmosphere of air reinforced approximately to 10 per cent in its carbon dioxide content. Cultures show that many patients considered free from infection still harbor the organism.

A frequent complication of gonorrheal salpingitis is pelvic abscess. Pus gravitates into the Douglas pouch and is walled off by omentum, loops of intestine, tubes, ovaries, and uterus, or a large pus tube or tubo-ovarian mass behind the uterus becomes fixed to the surrounding tissues. Such a mass made up of a single cavity or multiple abscesses may reach enormous size. Soon, through extension from the intestine, there is invasion of colon bacilli, streptococci, and anaerobic organisms. Such accumulations of pus respond poorly to non-operative procedures, though they may evacuate themselves spontaneously through the vagina or rectum. Operation, drainage, or removal by laparotomy is usually required.

Pelvic abscesses from postabortal or postpartum infection are next in frequency. The tendency of this variety of infection is to invade the parametrial tissues and form broad ligament or retroperitoneal abscesses. This type will be mentioned later.

The acute appendix is not an uncommon source of pelvic peritonitis and abscess. Norris[12] has emphasized the frequent association of appendicitis with pelvic peritonitis. The appendix is often found secondarily involved in a pelvic mass as a periappendicitis, or rarely it may undergo

suppuration. Coopman, as quoted by Wharton,[1] in 1915 stated that appendiceal involvement in cases of chronic purulent pelvic inflammatory disease in itself justifies laparotomy. Acute gonorrheal tubes are occasionally encountered during an operation for appendicitis. Though the convalescence may be somewhat shortened by their removal, such tubes should be left as infection will subside.

Pelvic abscess following ruptured ectopic pregnancy or postoperative accumulations of blood are encountered. Infrequently tuberculosis, carcinoma of the cervix, infected ovarian cysts, or uterine myomata are a cause.

Given a pelvic mass that can be drained by the vaginal route, a careful vaginal and rectovaginal bimanual examination is of prime importance in establishing the relation of the abscess to the uterus, bladder, broad ligaments, and rectum, determining at the time the most easily accessible and dependent part as well as any point of fluctuations.

Making an incision through the posterior vault of the vagina close to the cervix, a blunt instrument, dressing forceps or a curved clamp is now used to open the peritoneum. Some recommend previous exploration with a large bore needle. Having opened into the abscess, accessory pockets are felt for with the finger and punctured, with care not to break up adhesions which wall off the abscess from the general peritoneal cavity. In dealing with a gonorrheal abscess, soiling the peritoneal cavity is not regarded as serious; in the puerperal or pyogenic type, however, if the peritoneum is opened, the opening should be freely enlarged and thoroughly drained: a small hole is more dangerous than a large one.

It is unwise to explore the pelvis indiscriminately, and it is a safe rule that if a mass cannot be punctured easily it is better left alone. Openings into the general peritoneal cavity, the rectum, or bladder are dangerous complications.

The abscess cavity is drained by a hard rubber drain sewn to the vault. Irrigation of the cavity is inadvisable because of the danger of soiling the peritoneum. The drain remains in place for seven to ten days depending upon fever and the amount of drainage. Approximately one-fourth of the patients with pelvic abscess are permanently cured by drainage and an equal number are partially relieved; the remainder, because of adhesions, distortion of pelvic organs, continuance of pain and discomfort, and residual infection, seek surgical relief.

Chronic pelvic inflammation is a disease of great clinical significance. It is of wide occurrence with varied and far reaching constitutional results. The pelvic organs are dislocated and immobilized. Menstrual disorders, dysmenorrhea, menorrhagia, and metrorrhagia are not uncommon. Pain in the lower abdomen, on one or both sides, continuous or frequent with short intermissions, made worse by exertion; interference with intestinal function through adhesions, with indigestion, and constipation; backache, fatigue and nervousness are sequelae.

Rest, hot douches, local heat, the inductotherm, and diathermy are forms of beneficial therapy, but often the patient is so incapacitated that surgery is necessary. This is either radical or conservative; various problems present themselves which are to be solved by the experience and ingenuity of the operator. Surgeons differ considerably in their ideas as to when to be conservative. Each case must be decided on its individual merits.

It is generally recognized that final clinical and pathologic results of conservative operations are not so good in the percentage of cures as are properly performed radical operations. Adhesions reform, raw surfaces are not so easily peritonealized, and resected ovaries too frequently cause ovarian dysfunction.

Unless they are irreparably damaged, there are just objections to the removal of pelvic organs in the younger individual. Loss of sex feeling, mental depression, and

lack of proper adjustment are of greater importance than residual pain.

Pelvic cellulitis is a different type of infection from that ordinarily seen in gonorrhea. The extraperitoneal connective tissue is invaded by pyogenic bacteria traveling along the lymphatics, usually a direct extension from the uterus or cervix, resulting most commonly in postpartum or postabortal infections. There are other etiologic factors, such as postoperative infection, carcinoma, stem pessaries; in rare instances the antecedent factor is not discoverable. The common site is the fibrous tissue between the layers of the broad ligament, "parametritis." Though most often unilateral, it may spread widely, surrounding the rectum, neck of the bladder, extend upwards to the iliac fossa and perinephritic regions, or downward into the rectovaginal septum.

Such an infection may resolve or proceed to abscess formation pointing to the inner-side of Poupart's ligament anterior to the bladder, or along the posterior abdominal wall between the iliac crest and the last rib. Ischiorectal abscesses may form through the parametrial infection passing between the fibers of the levator ani muscles. Spontaneous rupture of these abscesses into the bladder, vagina or rectum is occasionally observed.

Symptoms of pelvic cellulitis—fever, pain and tumor—are varied. Fever is usually present. Pain, likewise, usually a prominent symptom, may be only a discomfort. Diarrhea and urinary frequency occur from involvement of these viscera in the infection. At times the only prominent sign of pelvic cellulitis is a tumor in the lower abdomen which usually represents involvement of one or both broad ligaments.

The diagnosis of pelvic cellulitis is made by pelvic examination, particularly rectal, which reveals induration in the base of the broad ligament with or without extension to other areas. Differential diagnosis is difficult inasmuch as complaints are of little value, the history often unknown or unreliable, and the pelvic findings may simulate closely those of intraperitoneal infections, carcinoma of the pelvic organs or bowel. Often one hesitates to diagnose pelvic findings as pelvic cellulitis until a definite etiologic factor is elicited.

In unrecognized or neglected patients with pelvic cellulitis, constitutional signs of loss of weight, anemia, and weakness appear. In the more virulent types there may occur associated septicemia, peritonitis, or thrombophlebitis. The termination may be fatal. Pulmonary emboli are encountered even in the comparatively milder cases.

Treatment is largely expectant. Surgery is to be avoided other than to evacuate pus. Incisions are to be made extraperitoneally where the pus commonly points; this is most frequently either above the inguinal ligaments or in the posterior fornix (vaginal approach). The method of approach through the groin was apparently first described by Hegar[8] in 1881 and was soon recognized and accepted as a valuable means of reaching the infection and staying outside the peritoneum. Recalling the spread of the infection, incision and drainage may have to be performed in other areas such as the flank, over the ischiorectal area, and occasionally over the femoral space. Laparotomy is to be avoided because of danger of soiling the peritoneal cavity with virulent pyogenic organisms which cause this type of infection. Resolution occurs most frequently without pus formation and is materially aided by bed rest and local heat. Transfusions are of considerable help when the patients are run down. Antistreptococcic serum has been advocated. More recently sulfanilamide has been used, particularly in postabortal or puerperal infections before parametrial infection has had an opportunity to arise.

In the treatment of puerperal sepsis due to hemolytic streptococcus, sulfanilamide has been exceedingly effective. When it is administered at the first sign of the disease Colebrook and Purdie[4] have shown that further spread of the infection is infre-

quent; that in 100 cases there was parametrial invasion in but five, and this small in amount. Another striking effect of the drug was its effect in the treatment of bacteremic cases. Fifty-three per cent recovered, and also three cases of general peritonitis.

Bacteriologic study of these cases makes it evident that the chances of a puerperal infection being of hemolytic streptococcal origin are very great. Ninety-two of 106 patients showed Lancefield Group A organisms, susceptible to sulfanilamide, two showed Group B, two Group C streptococci, and four Group G organisms.

Long and Bliss[11] state that there is experimental evidence from work on mice that sulfanilamide is fairly effective on Group C, only moderately so on Group B, valueless in sepsis caused by staphylococci or the anaerobic streptococcus, but excellent in Welch bacillus infections.

Colebrook and Purdie, as quoted by Long and Bliss[11] in a report of cases from Queen Charlotte's Hospital, showed that the average fatality rate of cases of hemolytic streptococcus septicemia had been 71 per cent during four years prior to the use of prontosil, while in the fifteen months in which the drug had been used the death rate was cut to 27.3 per cent.

If seriously ill, large doses of sulfanilamide are given, with a blood concentration of 10 to 15 mg. per cent: mild cases without bacteremia or peritonitis are given smaller doses, cutting the drug down one-third or one-half after symptoms subside, and the temperature has been normal for two days. Smaller doses are then continued for a few days longer.

It has been noted that the offending organism may be recovered from the genital tract for a considerable time after all treatment has been discontinued.

In an established case of cellulitis the usual response with conservative management is gradual improvement. The fever disappears, the pain is less, and the general condition improves. Often the regression of pelvic findings is very slow, and it has been noted that symptomatic improvement may take place with very little change in the pelvic findings. When the induration is hard and extensive, complete resolution may not take place for months or even years. Severe cases of pelvic cellulitis, usually associated with thrombophlebitis or septicemia, may prove intractable to therapy and end fatally. With a definite diagnosis of septic thrombophlebitis, ligation of the pelvic veins is sometimes indicated.

CONCLUSION

This article on salpingitis and pelvic cellulitis appears in a Symposium on Emergency Surgery. It is the consensus of opinion of leading gynecologists that the above conditions, when acute, are essentially non-surgical.

Certain complications of acute pelvic disease may require surgical intervention: pelvic abscesses, definite evidence of intestinal obstruction, or the rare complication of an intercurrent suppurative appendicitis. These complications are, however, the exception. Chronic pelvic inflammation may call for operation for relief from pain; by reason of adhesions, for menstrual disturbances, reinfection, and sterility.

When surgery is resorted to in pelvic parametritis it should be postponed until there is a definite abscess formation, as the infecting agent in these cases is usually the streptococcus which may retain its virulence indefinitely. The longer the delay, the safer the operation.

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To this day there are practising in India itinerant cutters for stone . . . The operator puts his finger in the patient's anus and hooks down the stone, which can be felt in the bladder, so that it presses hard against the perineal tissues. With an ordinary razor an incision is made over the flinty protrusion and deepened until the bladder is opened. The stone is extracted with a scoop and that is all.

ABSCESS OF THE PROSTATE AND SEMINAL VESICLE

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INTRODUCTION

ABSCESSES of the prostate and seminal vesicles are more often encountered in hospital practice among the very poor than in private practice because they are usually due to neglect of an infection. They may, however, occur in any patient. These two conditions do not necessarily occur simultaneously, and, in fact, rarely do, although each may develop separately from the same infection. They will, therefore, be considered in separate chapters.

PROSTATIC ABSCESS

Etiology. Abscess of the prostate results from a breaking down of the tissues whenever multiple small abscesses, formed in cases of fulminating prostatitis, fail to subside.

A frequent cause of prostatic abscess is the gonococcus, but our own studies have shown that many other organisms may be present in abscess cavities in the prostate: Staphylococcus aureus, Staphylococcus albus, Streptococcus viridans, Staphylococcus pyogenes hemolyticus, Micrococcus tetragenus, Bacillus proteus, B. pyocyaneus, B. coli communis, and B. typhosus.

It is a strange but true fact that a prostatic abscess caused by the gonococcus frequently fails to show the organisms in the pus from the abscess cavity even though they may exist in profusion in the urethral discharge. In such cases the abscess fails to grow any organism. Eight of our forty-six cases were sterile.

Prostatic abscess may and often does result from too strenuous urethral instrumentation. Cases may also occur as a complication of influenza, typhoid fever, septicemia, diabetes mellitus, carbuncles, boils, or felons. In the three last mentioned conditions the causative organism is the Staphylococcus aureus.

In a careful study by Hawes and Yunck of fifty-nine cases of prostatic abscess occurring on our service, twenty patients denied ever having had gonorrhea and ten had had the disease many years previous to the development of the abscess. These patients varied in age from 17 to 80 years. Thirteen were not operated upon, and forty-six were. Of the patients operated upon, thirty-two were between the ages of 20 and 40 years, one was in the second decade, seven in the fifth, three in the sixth, one in the seventh, and two were over 70 years of age.

Pathology. Abscess is a sequel of acute prostatitis. It is the fourth stage of an inflammatory process. A preliminary acute catarrhal inflammation is followed by follicular prostatitis, which is marked by the presence of multiple minute abscesses and dilatation of the prostatic tubules with pus, because during the inflammatory stage they fail to drain. The third stage is called parenchymatous prostatitis, and is an intensification of the second stage. The small abscesses become more marked, and the prostate is enlarged, tender, and hot. The inflammatory process either resolves under treatment or extends, with a resulting confluence of the small abscesses to form a large, fluctuating mass which may involve a large part of the gland.

Occasionally the accompanying periprostatitis forms an additional abscess, which extends rapidly and may even surround the rectum. Rarely a prostatic abscess may adhere to the rectum and rupture through, discharging its contents into that viscus.

Symptomatology. The usual symptoms of prostatic abscess are pain in the peri-

neum, difficulty in passing urine, chills, and fever. The leucocyte count is usually high, in our series varying from normal to

Diagnosis. A history of pyogenic infection, even in a distant part of the body, together with urinary disturbance is sug-

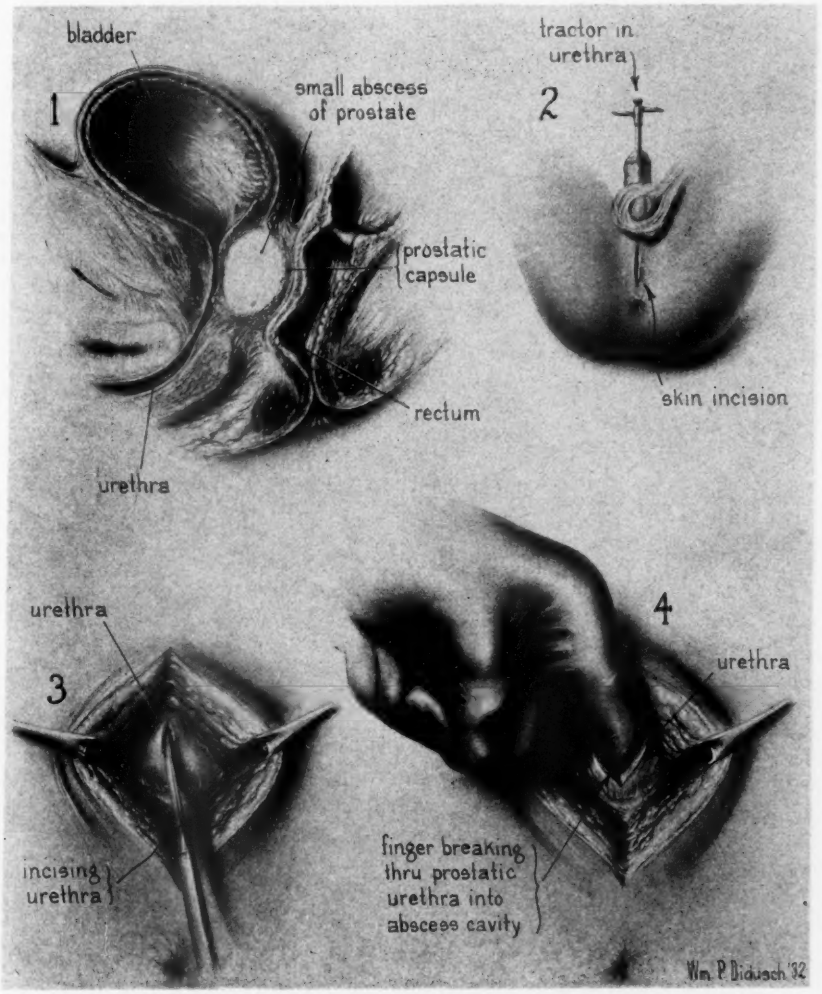

FIG. 1. 1, sagittal section showing a small abscess of the prostate gland. 2, Lowsley tractor in place. 3, incision through the external sphincter of the urethra. 4, finger introduced into prostatic urethra.

as high as 30,000. A cause of wonder to urologists is that there are occasional cases of huge prostatic abscess in which the only symptom is difficulty of urination. Eighteen of our patients had complete retention of urine.

There may be neither pain, fever, nor a high leucocyte count. The explanation of this lies in the type and lack of toxicity of the infecting organism.

Chronic abscess of the prostate may develop insidiously and persist for weeks without causing any distress whatever.

gestive of the presence of a prostatic abscess.

The diagnosis usually is not difficult. It is based on two types of examination. First and most important is rectal examination. The palpating finger will detect an enlargement of the prostate gland; this is tender, hot, and often asymmetrical. The presence of fluctuation leaves no doubt about the diagnosis. If no fluctuation is detected, a needle may be inserted into the suspected portion of the gland and pus withdrawn, if present.

If no fluctuation or pus is noted, a cystourethrogram may be helpful in arriving at a correct diagnosis. The urethrogram will show a large spread of the prostatic portion of the urethra, and the shadow of the abscessed portion of the gland projecting into the bladder, as shown in the cystogram, will be suggestive.

Prognosis. The prognosis is very poor if the abscess is untreated. The abscess may rupture into the urethra or rectum, or it may burrow into the perineum, bladder, or even into the peritoneum. In such cases the mortality is high, and, if death does not ensue, the convalescence is prolonged and complications serious.

If proper drainage is instituted the convalescence is usually satisfactory, although every prostatic abscess must be followed by a long course of treatment to ensure a normal gland.

Operation upon a prostatic abscess may be followed by impotence, due to the unbalance of the perineal musculature by the necessary dissection to expose the prostate. Such cases are all curable by the Lowsley plastic operation for the cure of impotence.

Thirteen of the patients in our series escaped operation and were cured by palliative means. Three of the forty-six patients operated upon died. One had multiple abscesses following an infection of his finger. The prostatic abscess was a part

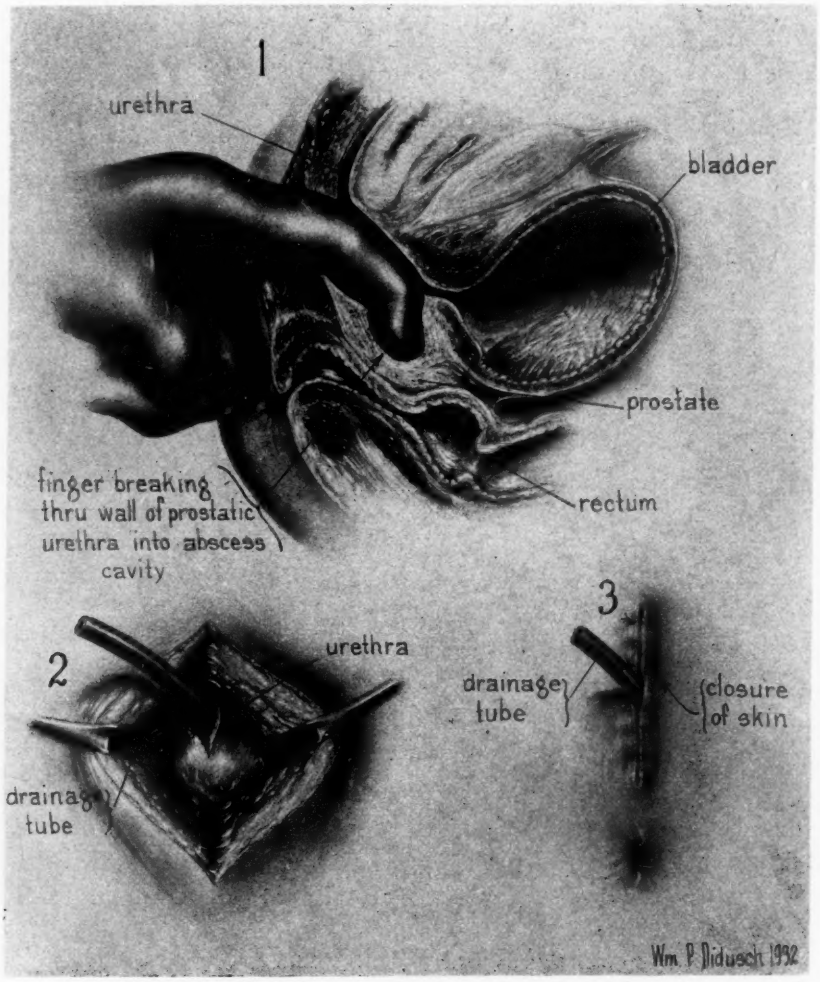

Fig. 2. 1, sagittal section showing the finger introduced into the prostatic urethra and into the prostatic cavity, breaking down the honeycomb arrangement of the abscess cavity. 2, showing a drainage tube in the urethra. 3, closure of the skin.

of the general infection. Staphylococcus aureus was obtained from the blood stream. The second death occurred in a diabetic who had a Staphylococcus aureus infection of his prostate with abscess-formation. He expired on the eleventh postoperative day, having developed a Staphylococcus aureus blood stream infection. The third death occurred in a patient who had ulcerative colitis and developed a prostatic abscess which showed enterococci in the pus evacuated.

Treatment. The treatment of prostatic abscess consists of (1) medication by mouth; (2) diet; (3) local measures; and (4) surgery.

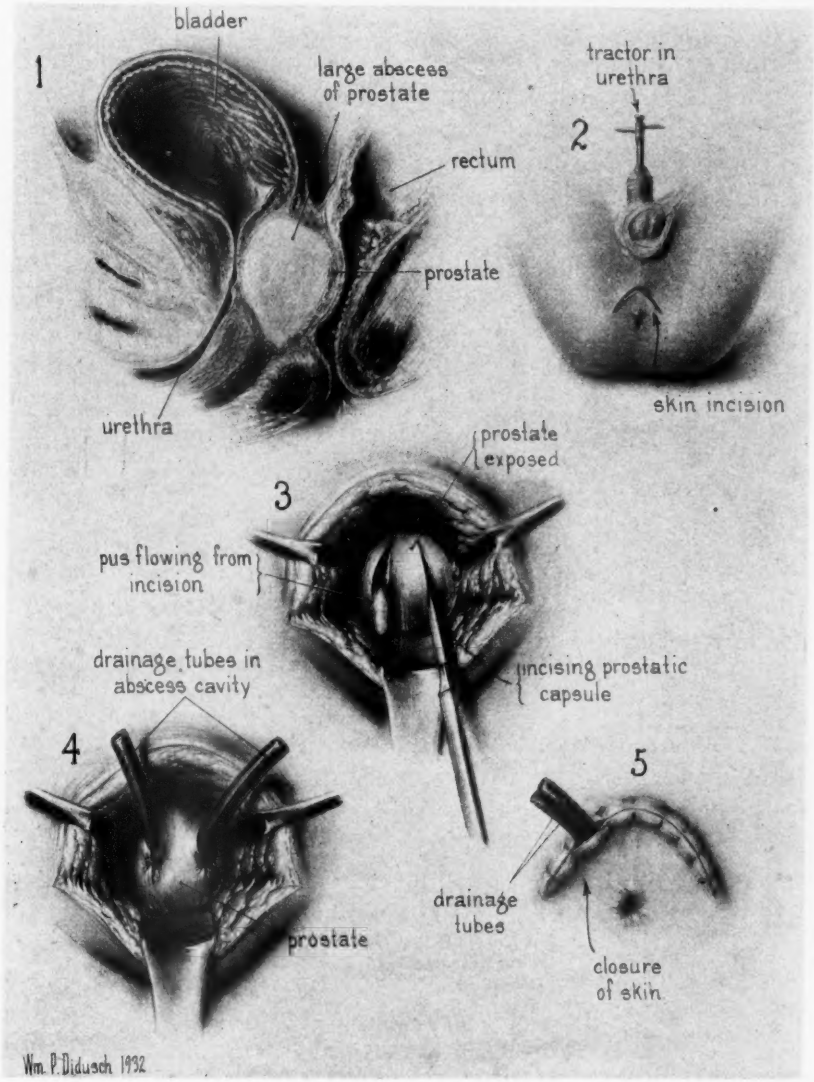

Fig. 3. 1, a large abscess of the prostate. 2, tractor in place, an inverted v incision having been made in the perineum. 3, the bulging prostate is incised, releasing pus from the incision. 4, two small soft drainage tubes are shown fixed in position in the prostatic abscess. 5, closure of the wound with both tubes coming through the same aperture.

Medication. Urinary antiseptics should be given all patients suffering from infection of the prostate—not with the idea of curing the disease, but to prevent extension of the disease into the upper urinary tract.

The drugs most commonly used are methenamine combined with acid sodium phosphate or ammonium chloride, acriflavine, and, latterly, sulfanilamide in an

alkaline medium, avoiding any substance containing sulfates, such as magnesium sulfate, eggs, etc.

Diet. The diet should consist mainly of fluids until the acute stage is passed, and then a low protein diet, free from alcohol, red meats, tomatoes, berries of all sorts, carrots, and condiments, should be given.

Local Palliative Measures. Local palliative measures consist of the application of heat to the affected gland. This is best accomplished by the use of hot rectal douches several times daily. If this is impractical, hot sitz baths are helpful. Metal rectal tubes, through which a constant flow of hot water may be passed, are sometimes useful.

Surgical Treatment. A cardinal principle in the treatment of contained pus is to evacuate it. This may be accomplished in a number of ways. The method of choice is to do a perineal section, introduce the finger into the prostatic portion of the urethra and then into the abscessed portion of the gland, and clean out the honeycombed interior so that no pockets are left. A tube is then introduced into the bladder, diverting the urinary stream and leading the pus out through the perineal wound.

Another method of drainage is to expose the posterior surface of the prostate gland just as one does in doing the Young perineal prostatectomy, and then incise the abscess cavity and insert and fix a tube into it.

A third method of evacuating a prostatic abscess is to insert a large needle into the cavity through the perineum, with the finger in the rectum as a guide, and withdraw the pus through a needle with a syringe, as proposed by Barringer. This method is unsatisfactory, however, as drainage is not complete and the procedure usually has to be followed by open operation.

Still another method is the sound procedure suggested by Stevens. This consists in passing a sound into the prostatic portion of the urethra, where it is manipulated in such a manner that its end digs into the abscess cavity, evacuating it. Unfortunately, this type of drainage is not complete, and the honeycombed interior of the abscess cavity makes for slow convalescence.

ABSCESS OF THE SEMINAL VESICLE

Etiology. Abscess of the seminal vesicle is an uncommon lesion. It may follow gonorrheal infection, tuberculosis (rare), or nonspecific infections from the colon bacillus, Staphylococcus aureus, etc. Prolonged congestion due to long-continued sexual excesses in the presence of infection (specific or nonspecific) may lead to abscess formation.

Infection may reach the seminal vesicles by extension from the prostatic urethra, either directly or by lymphatic invasion; or it may descend from above by extension from the genital tract; or it may be blood-borne.

Pathology. Seminal vesicular abscess follows acute vesiculitis. The vesicle may pass through three stages in the formation of an abscess. First there is an early catarrhal seminal vesiculitis. The vesicle is enlarged, soft, and drains freely on pressure. This is followed by an intermediate catarrhal condition in which the vesicle is still larger, piriform in shape, and drains poorly upon massage or ejaculation. The expelled fluid may be blood-stained and contains much pus. The third stage is abscess formation. The seminal vesicle is greatly enlarged, very hot, and tender. As a rule, no fluid is obtained upon massage. If fluid is obtained, it will be mucopurulent, often showing some red blood cells.

In later stages periseminal vesiculitis may occur. In such cases the vesicle is surrounded by an area of brawny edema which may simulate malignancy.

Abscess may occur in a seminal vesicle as an accompaniment of tuberculosis. When this happens, the bead-like appearance of the seminal vesicle usually seen in tuberculosis will be replaced, in part or all of the vesicle, by an abscess cavity.

Symptomatology. Acute seminal vesiculitis with abscess formation usually is accompanied by chills, fever, headache,

and other symptoms of general toxicity. Fever may, however, be absent. Frequency and dysuria are usual accompaniments. Pain is present and usually severe. It may be referred to the small of the back, suprapubic region, hips, or down the inside of the thighs. Cramp-like pains occasionally occur over the course of the ureter on the side corresponding to the affected vesicle, and may even extend into the kidney region. Pain following the sexual act is very common.

Objectively, there is extreme pain on digital examination. Enlargement of the vesicle is pronounced and fluctuation is frequently detectable. The heat in an abscess of a seminal vesicle can frequently be felt by the palpating finger. Pus and blood are observable in any fluid that may be expressed.

It is possible for a huge abscess to be present in a seminal vesicle in the complete absence of symptoms pointing to this region. In some cases there may even be no elevation of temperature and no change in the blood count.

Diagnosis. A history of preëxisting infection is suggestive. Digital examination of the region is helpful, and seminal vesiculography gives actual proof of an abscess if one is present.

If there is no history of infection and no symptoms pointing to the genitourinary tract, a history of arthritis should lead one to suspect the seminal vesicles if the teeth, tonsils, and sinuses are negative.

A rectal examination reveals the size of the seminal vesicle, as well as the condition of the prostate. A vesicle that is large, hot, tender, and fluctuating leaves no doubt as to the diagnosis. In some cases, however, the vesicle may be large, not tender, and surrounded by such an area of edema that there is doubt regarding the presence of an abscess.

The seminal vesicular secretion is usually easy to obtain. If a sterile endoscopic tube is passed into the prostatic urethra before massage, the secretions may be obtained under sterile precautions without contamination of the flora of the anterior urethra. Lowsley and Delzell, using this method, found the gonococcus, Staphylococcus aureus, Staphylococcus albus, Staphylococcus viridans, Staphylococcus hemolyticus, Streptococcus viridans, Streptococcus hemolyticus, Bacillus coli communis, Micrococcus tetragenus, Bacillus pyocyaneus, Bacillus proteus, and a diphtheroid bacillus. Thus it is seen that many organisms may penetrate the seminal vesicles.

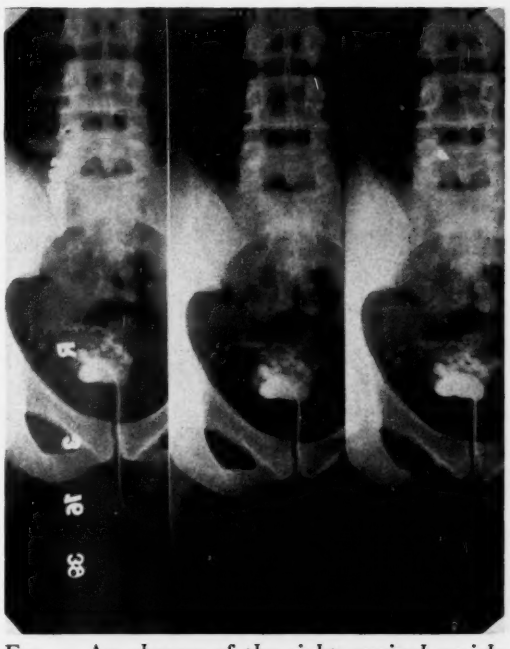

Fig. 4. An abscess of the right seminal vesicle injected through a catheter passed into the ejaculatory duct; the ampulla of the vas and the vas itself are also outlined.

Vesiculography. Advances in seminal vesiculography by Lowsley, Delzell, Peterson, and others have brought to the urologist a distinct aid for the diagnosing of abnormal conditions of the seminal vesicles. These have been made possible by the improvement in instruments.

Radiography, after the injection of neoiopax, sodium iodide, or other opaque media into the ejaculatory ducts by means of a small catheter through the Lowsley-Peterson urethroscope, gives excellent pictures of the seminal vesicles, permitting accurate diagnosis of an abscess if one is present.

Prognosis. Unless the abscess si fairly large, palliative measures may be successful in causing absorption. Large abscesses demand surgical drainage. Such cases, when properly drained through a perineal incision, usually do well. Following surgical intervention many patients have a temporary, or even a permanent, impotence. This is due to a disturbance of the perineal musculature, and can be cured by the Lowsley plastic operation, in which the bulbocavernosus and the two ischiocavernosus muscles are plicated with chromic ribbon gut.

Treatment. Treatment may be palliative or surgical. If the abscess is not too large, palliative measures of various kinds may suffice.

Medication. Sulfanilamide has been found useful in many cases. Forty grains daily, in divided doses, should be given for one week. While taking this drug the patient must take sodium bicarbonate and refrain from the use of epsom salts, eggs, and other substances containing sulfur compounds.

Methenamine and an acidifying agent are often useful when sulfanilamide fails or cannot be taken.

Local Treatment. Local therapy consists chiefly in the application of heat. This is accomplished by giving a hot rectal douche twice daily. The water should be at least 110°F. If this is not feasible, a hot sitz bath twice daily usually helps. The Elliott bag and the so-called rectal cooling tubes made of metal are other ways of applying heat to this region.

Often drainage may be aided by dilating the ejaculatory ducts with bougies through the urethroscope. Antiseptic solutions may be injected into the seminal vesicles and are in some instances helpful.

Surgical Treatment. Surgical treatment is accomplished by a perineal approach. After exposure, the seminal vesicles may be removed or incised and drained, depending upon the condition found by the surgeon. Under ordinary conditions excision is preferable.

Exposure of the seminal vesicles is accomplished as follows: The patient is placed on the table in an exaggerated lithotomy position. A Lowsley prostatic tractor is passed into the bladder, opened, and the prostate and seminal vesicles pulled up as far as possible.

An inverted v incision is made in the perineum. This is deepened into the rectal fossa on each side. The central tendon is cut and the anterior tractor is placed behind the transverse perineal muscles, which are pulled upward.

The apex of the prostate is located, the rectourethralis muscle cut, and the levator ani muscle is dissected away from the posterior surface of the prostate and seminal vesicles, which is recognized by its glistening fascia of Denonvilliers.

The rectum is separated from the posterior surface of the seminal vesicles and held out of the way with a gauze-covered posterior retractor.

A transverse incision is made into the two-layered posterior portion of the reflection of the peritoneum which covers the vesicles. (Unless both layers of this envelop are incised the seminal vesicles are not to be seen.) The vesicles are then dissected free, and incised or excised, as desired. If excised, the proximal ends are tied off and carbolized, and the ampullae are incised. Small, soft-rubber drainage tubes are sewed in position.

The wound is closed by one stitch of plain catgut, drawing the two sides of the levator ani muscles together. The skin is closed with silk or dermal.

ISCHIORECTAL ABSCESS

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ACUTE abscess in the anorectal region is usually due to infection by the common pyogenic organisms following irritation, traumatism, inflammation, or ulceration in the anal canal. It has its point of origin most often at the pectinate line in one of the anal crypts. In relation to the anus and rectum, abscess occurs in various anatomic locations, thus:

1. If the infection extends upwards in the rectal wall the abscess originates in the submucosa. This location is rare.
2. Usually the abscess is outside the gut wall in one of three positions:
   (*a*) Above the pelvic diaphragm in the superior perirectal space.
   (*b*) Subcutaneous around the anus.
   (*c*) In the ischiorectal fossa.

Of the above locations the most frequent position of abscess in the anorectal region is in the ischiorectal fossa.

CAUSE OF ISCHIORECTAL ABSCESS

Besides chemical irritation and traumatism caused by the passage of bowel contents to the lower part of the rectum and anus, ischiorectal abscess may follow injury by the passage of foreign bodies, such as seeds, fragments of bones, toothpicks, or pins. These foreign bodies may become lodged in the anal canal due to the abrupt narrowing of the bowel at this point and the direction upwards of the anal crypts. When infection gains a foothold in such an injured area it tends to spread along the lymphatics or through the gut wall at the point where the levator ani and longitudinal muscular coat of the bowel pass between the sphincters, and in this way may reach the ischiorectal fossa.

Many ischiorectal abscesses result from the spread of infection from a neglected posterior anal fissure. They also may be caused by strangulated, gangrenous, infected hemorrhoids. Occasionally abscess may follow anorectal operations due to spread of infection into deeper tissues but most often postoperative infection gives rise to a subcutaneous type of abscess.

In addition to the above causes infection and ulceration may originate in the anal crypts and terminate in ischiorectal abscess. Tubercle bacillus, gonococcus, and Vincent's organisms may be considered as causes.

Also an infection of an abrasion of the skin or acute inflammation of perianal skin without abrasion or ulceration may through the lymphatics terminate in an ischiorectal abscess. Infection may occur by direct extension from retrorectal or superior pelvirectal spaces, or from urogenital organs.

SPREAD

When an abscess originates in the ischiorectal fossa it spreads through the loose adipose tissue without causing any obvious swelling until considerable tension is present. As it continues to develop it is limited laterally by the obturator fascia which covers the obturator muscle, and above and behind by the levator fascia which covers the lower surface of the levator ani muscle. The levator ani practically surrounds the rectum posteriorly in such a way as to form a space at the back of the anorectal junction through which the ischiorectal fossa may communicate with the one on the other side.

As the tension in the abscess increases it tends to burrow in the line of least resistance: it may travel downward to open on the skin surface, or along the anal

portion of the levator fascia, which is directly attached to the muscular coats of the anal canal between the two sphincters, to open into the anal canal at the anorectal junction. However the infection may spread directly through the posterior passageway between the sphincters behind the rectum to the opposite side.

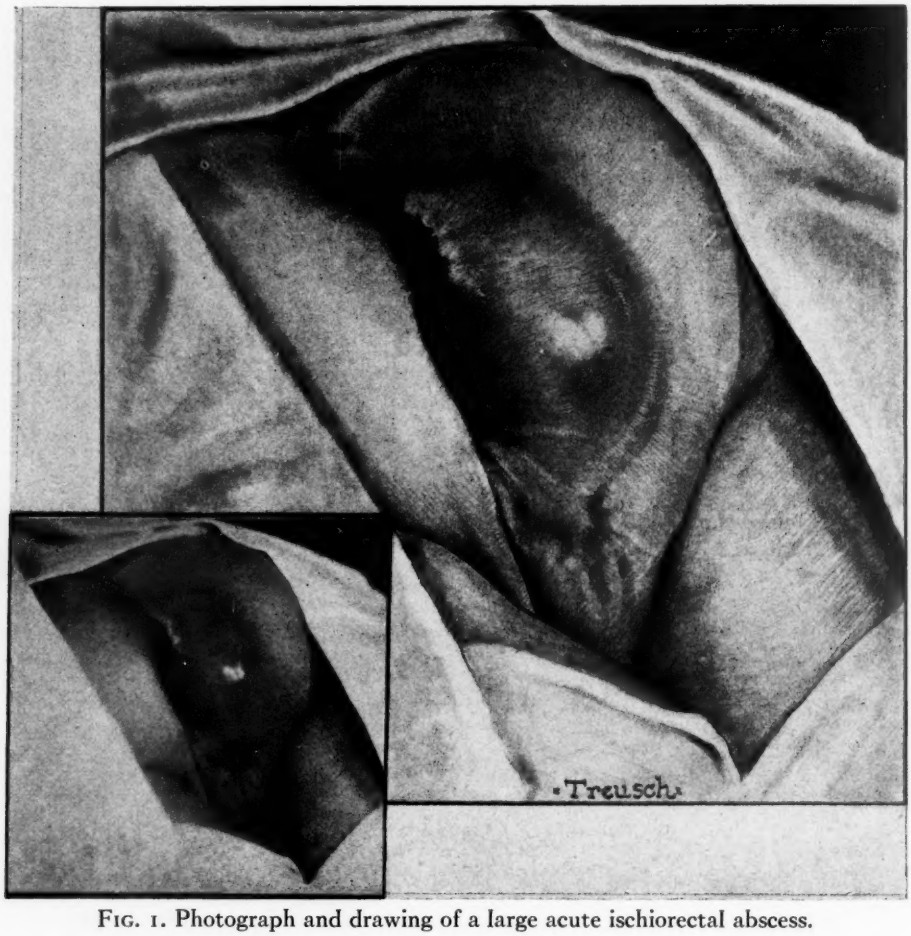

FIG. 1. Photograph and drawing of a large acute ischiorectal abscess.

Infection in the anal canal, especially along the pectinate line posteriorly, may pass through the lymphatics to either fossa or to both, though the infection usually develops more rapidly on one side than the other. When both sides are involved it is known as a "dumbbell" abscess: such an abscess tends to terminate in a "horseshoe" fistula with the internal opening located at the posterior midline in the anal crypt. This indicates that the origin of the infection which terminates in an ischiorectal abscess was probably a posterior fissure or infection of an anal crypt. A pelvirectal abscess may rupture into the ischiorectal fossa and in this way cause a pelvirecto-ischiorectal abscess. It is rare for an ischiorectal abscess to extend upwards into the pelvirectal space. In some cases it may extend between the sphincters upwards and form a submucous abscess.

The ischiorectal fossa is pyramidal in shape and is situated on each side of the anus and lower part of rectum external to the sphincter muscles. Under extreme tension it may distend to hold 4 to 8 ounces of pus. When more than this is evacuated one must suspect that an abscess in the superior pelvirectal space has perforated through the levator ani, forming a secondary ischiorectal abscess. The combined locations makes a condition very complicated and difficult to treat.

The possibility of tuberculous abscess in the ischiorectal fossa will not be discussed in this paper as it is rare: such abscesses usually result as a secondary extension from above in the tuberculous patient.

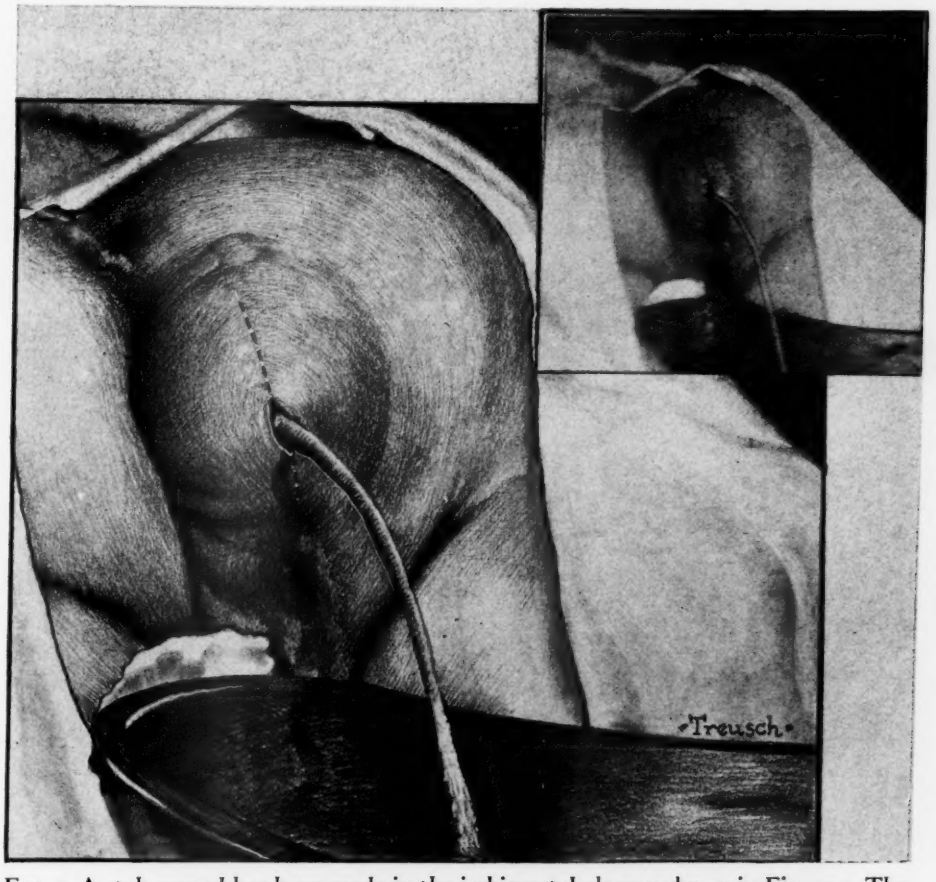

Fig. 2. A stab wound has been made in the ischiorectal abscess shown in Figure 1. The pressure within is illustrated by the force of the stream of pus spurting out of the abscess cavity through the stab wound photographed at the time of the incision. The dotted line indicates enlargement of the stab wound to permit evacuation of the pus and exploration of the extent of the cavity.

SYMPTOMS

Ischiorectal abscess develops as an acute local inflammatory condition. The patient complains of chilly sensation, headache, fever, and at first local discomfort. As the abscess develops and tension increases the discomfort becomes a constant dull aching and a feeling of pressure which is not relieved by enema or defecation. Later this aching develops into an intense throbbing pain.

At first there are no apparent local signs but soon induration may be felt along the side of the anus, followed by increase of local temperature, redness and discoloration, the degree of which depends on the depth of the infection. When the abscess begins high in the ischiorectal fossa it may be necessary to introduce the finger in the anal canal and press outward to determine early induration and swelling. When the abscess has existed two, four, or more days a tense inflamed swelling which may or may not fluctuate is present at the side of the anus external to the sphincter muscles. If allowed to continue, it will open spontaneously as a rule on the skin surface or in the rectum at the anorectal junction.

TREATMENT

From the etiologic factors involved one may appreciate the importance of preventive measures. These include avoidance of both constipation and of drastic purgatives, the avoidance of injury from enema tips, and care not to swallow seeds or other foreign bodies. It also is important to clear up local pathology.

When an ischiorectal abscess has developed, only one method of treatment should be considered: namely, opening and draining the abscess at once. As soon as the tension is relieved the abscess ceases to spread and an early incision may prevent subsequent fistula. Little if any result should be expected from the common use of rectal suppositories. If for some reason operation cannot be done immediately, hot fomentations and hot sitz baths tend to relieve pain and make the patient more comfortable. However, to temporize with such measures in hope that the abscess will subside is useless. To wait for the abscess to open spontaneously prolongs the patient's suffering and as the size of the abscess increases, it means healing will be prolonged and a fistula will almost certainly follow.

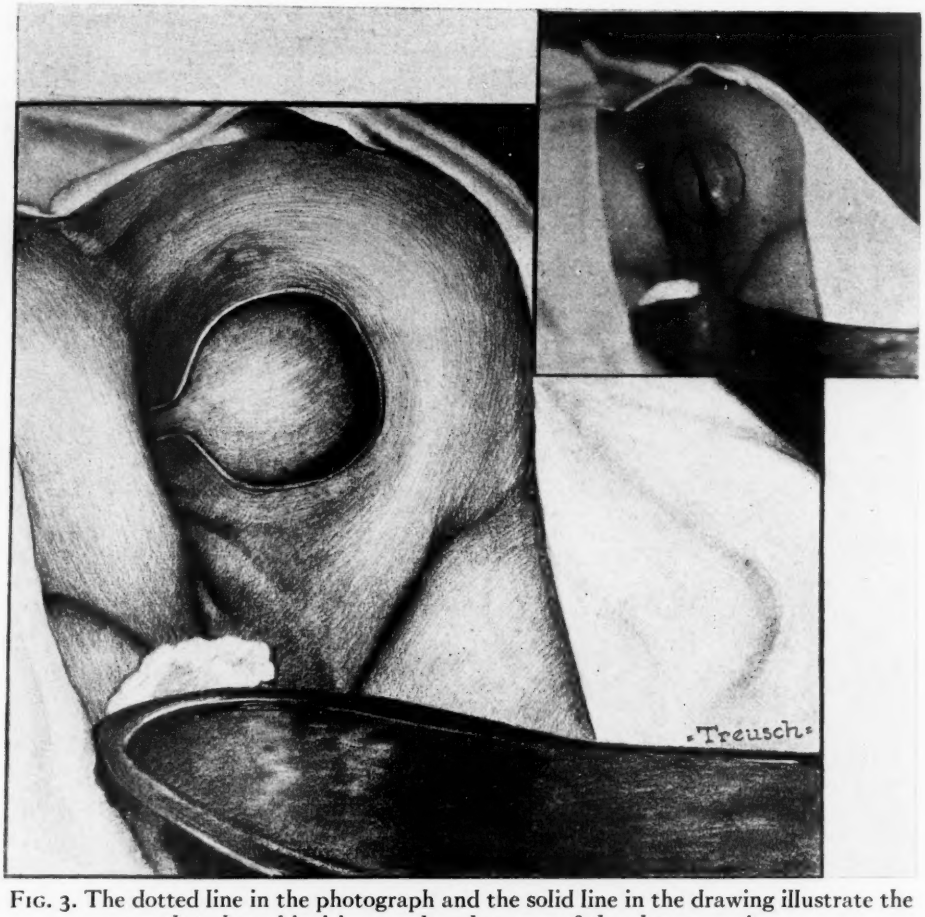

FIG. 3. The dotted line in the photograph and the solid line in the drawing illustrate the racket-shaped incision employed to unroof the abscess cavity.

In cases where the induration and tumefaction are such as to bring up the question of gas gangrene infection, it seems wiser to administer sulfanilamide in large doses and wait. Often sulfanilamide gives relief of symptoms and causes the acute infection to subside. Then follows general improvement of the patient. Certainly this method of treatment is advisable until the question of gas gangrene is cleared up, as incision into such infection before pus formation is of doubtful value and may spread the infection.

Anesthesia. General and low spinal are the ideal methods of anesthesia.

Local infiltration of nupercaine (1:1,000) or procaine (1 per cent), etc. superficially over the area to be incised, are commonly used, but this anesthesia may be incomplete and at times limits the operation.

Never use ethyl chloride spray, as the anesthesia is incomplete, the extent of area limited, and the discomfort from the anesthetic agent is usually greater than the anesthetic effect.

Operation. The location and type of incision to be made depends on the extent of abscess at the time of opening. As a rule the incision should be made lateral to the external sphincter muscle into the most prominent area of swelling or induration. Incision into indurated area even before pus is formed may at times be advisable to relieve tension. It may prevent further spread of the abscess. The incision should be sufficient in length to give free drainage. To make a small stab incision into an abscess cavity and then plug it with gauze prevents drainage and can only cause pain to the patient. After drainage is established with a good free incision there is no advantage in irrigation or breaking up of the abscess cavity. Hot sitz baths not only make the patient more comfortable, but help to cleanse the parts and keep up drainage.

When the abscess is large and there is marked swelling of perianal tissue, an anteroposterior incision is made over the most prominent portion of the swelling across the entire width of abscess (Fig. 2); this incision should be made lateral to the sphincter. The finger is now gently introduced into the wound and the extent of the abscess cavity determined. Then with scissors or knife the roof of the cavity is cut away and the incision is continued into the anus, sparing the sphincter muscle, leaving a racket-shaped opening. (Fig. 3.) This racket-shaped incision is made so that if a fistula should develop the external opening would be in the handle of the racket near the anal margin and not far out on the buttocks as in a T-shaped incision where the lateral incision extends outwards. The reasons for the incision are: to remove the skin wall over the abscess cavity; to decrease the depth of the cavity; to bring the last part of the abscess cavity to heal near the anal margin; and to place the handle of the racket as far back towards the posterior anal margin as possible. It may be necessary to cut away much of the cutaneous structures. Packing should be avoided other than for control of hemorrhage. The patient is put to bed and in about two days hot sitz baths are begun. It is hardly believable how rapidly the cavity of the abscess may be covered over with new skin. The cutaneous structures should be kept open until the abscess cavity can heal from the bottom. The patient should be told that a fistula may follow and a later operation for this may be necessary for a cure.

As a supportive postoperative treatment sulfanilamide in large doses often aids much in clearing up the infection, promoting rapid healing, and preventing a fistula. For some time this has been included in my postoperative routine.

To open an ischiorectal abscess in the acute stage and then proceed to do a radical operation for a fistula (cutting the sphincter muscles) may often leave a large open wound, marked retraction of sphincter muscle, followed by much scar tissue and deep sulcus in the anus and often partial or complete incontinence. Drainage of the abscess cavity as described above is all that should be undertaken in the acute case.

THE EMERGENCY TREATMENT OF THROMBOTIC AND PROLAPSED HEMORRHOIDS

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SINCE not all thrombosed hemorrhoids are prolapsed, and only a small portion of the cases of prolapsed hemorrhoids are thrombosed, the emergency treatment of these conditions will be discussed separately.

ACUTE THROMBOTIC HEMORRHOIDS

A thrombosed hemorrhoid may also be characterized as a "hemorrhagic pile," or a perianal hematoma.

Acute thrombotic hemorrhoids are caused by the rupture of some of the branches of the external hemorrhoidal veins. Internal hemorrhoids are infrequently thrombosed and as a rule only as a result of extraordinary trauma to those chronic internal hemorrhoids which usually have tended to prolapse. Both conditions are acute, and both conditions require emergency treatment.

Acute thrombotic external hemorrhoids occur much more frequently. They may occur as the result of trauma produced by constipated stools, fecal impactions, or foreign bodies. They may be produced also by traumatization during the careless insertion of examining instruments, or by foreign bodies inserted voluntarily by patients, or as a result of "hazing" by companions or fellow workmen. The trauma produced by the sudden descent of the diaphragm in sneezing, coughing, explosive laughter, the expulsion of large quantities of flatus, or following the expulsion of frequent irritating fluid stools, may also contribute to the production of acute external thrombotic hemorrhoids. Other causes are sudden jars, force, or local strain.

Sometimes one or two acute thrombotic hemorrhoids may be present without the patient's knowledge until he feels them as rounded protrusions in the anal vicinity when cleansing himself following a bowel movement. At other times their appearance is accompanied by sudden severe lancinating pain.

External thrombotic hemorrhoids are easily differentiated from internal prolapsing hemorrhoids by the fact that they are covered with *skin;* while internal hemorrhoids are always covered with *mucous membrane.* Regardless of the amount of eversion, protrusion or prolapse, the covering of the hemorrhoid decides the type.

Patients, and sometimes even physicians, push acute thrombotic hemorrhoids, partially or completely up into the anal canal, or at least attempt to do so, and thus add pain and trauma to the suffering already present. External inspection of the parts should decide the diagnosis and indicate the proper treatment.

The acute pain which usually accompanies the appearance of acute external thrombotic hemorrhoids may be relieved temporarily by the use of hot compresses of a saturated solution of magnesium sulfate, glycerin, or 50 per cent witch hazel. Probably the best method of applying heat is to have the patient take a hot sitz-bath. A twenty minute immersion in water as hot as can be borne, will relieve pain and swelling in most every case.

Acetylsalicylic acid or other sedative remedies by mouth are also indicated, as are codeine, morphine, pantopon, dilaudid or other opiates hypodermically or orally. After several applications of the hot compresses or sitz-baths taken at two or three hour intervals, the pain and swelling may subside to such an extent that operative methods may not be necessary at the time.

However, in the majority of cases if the clots are not evacuated they tend to become infected and abscesses result; or pressure necrosis will cause ulceration of the integument covering the growths. Sometimes this pressure is so great that a gangrenous condition will occur.

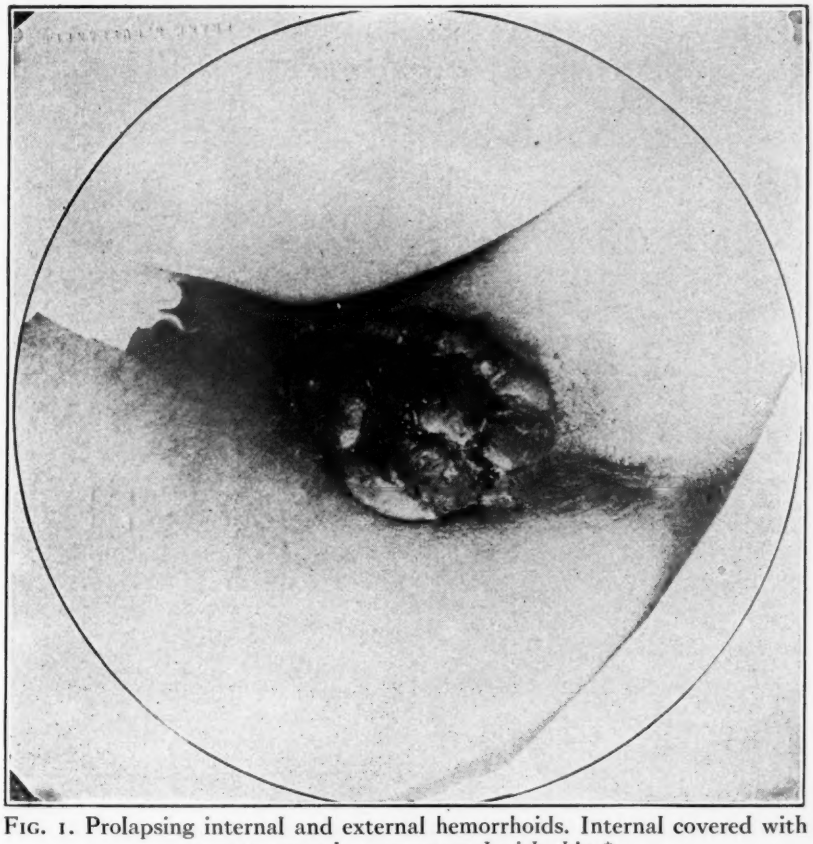

Fig. 1. Prolapsing internal and external hemorrhoids. Internal covered with mucous membrane; external with skin.*

A simple technique for the removal of acute thrombotic hemorrhoids under local anesthesia is described:

Operative Treatment under Local Anesthesia. The patient is placed on the table in the left lateral or Sims' position. A 20 c.c. glass hypodermic syringe is filled with the solution of choice. Procaine (0.5 per cent) is used for anesthetizing the sphincter and is injected in the following manner: A point ½ inch below the posterior to the posterior commissure of the anus is selected. The application of a swab dipped in phenol is used to deaden the pain which accompanies the introduction of the needle. The needle is passed inward, upward and laterally in a V-shaped direction for about ¾ inch, down into the sphincter muscle, but not through it. From 2 to 5 c.c. of the solution is slowly injected and the needle is retracted to the point of puncture, but not withdrawn; then it is pushed up on the other side in the same manner, keeping about ½ inch away from the anal aperture.

At least five minutes are allowed to give time for complete anesthesia. The sphincter will then be found sufficiently relaxed for any ordinary anorectal operation.

If but a single acute external thrombotic hemorrhoid is present, all that is necessary is to inject the hemorrhoid from its outer aspect with about 1 c.c. of a ½ per cent procaine solution. The injection is made subcutaneously, and not intradermally. The skin should be slightly raised up by the injected solution. The needle is then with-

* The illustrations in this article are reproduced from Hirschman's "Synopsis of Ano-Rectal Diseases," published by Mosby.

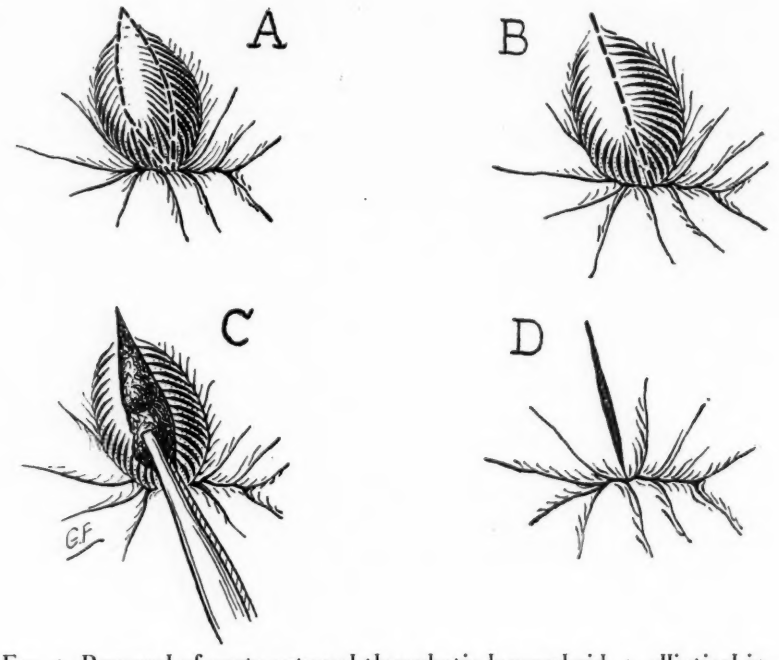

FIG. 2. Removal of acute external thrombotic hemorrhoid. A, elliptical incision. B, radial incision. C, removal of clots. D, edges of incision falling together after removal of clots.

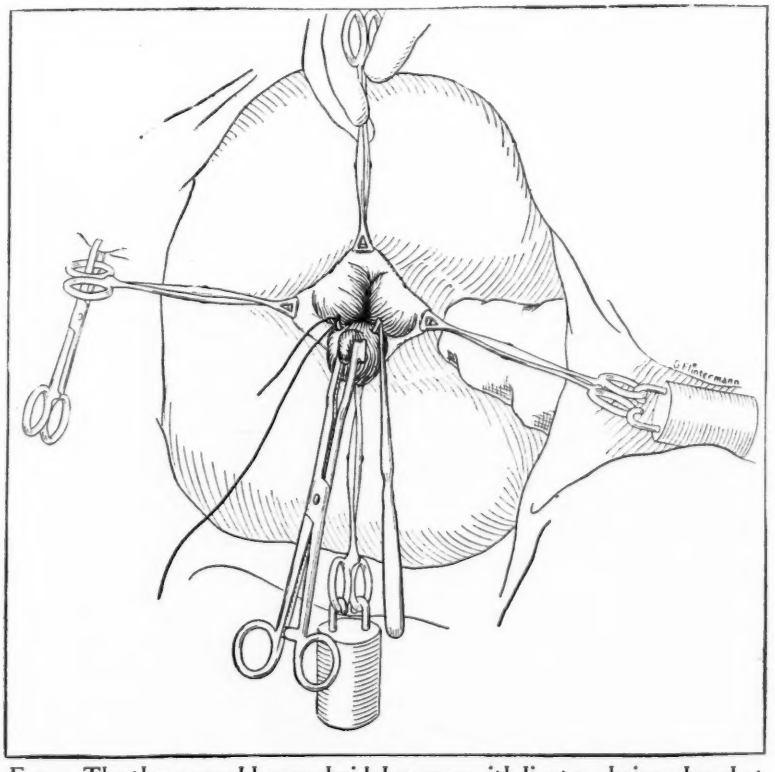

FIG. 3. The three usual hemorrhoidal groups with ligature being placed at the base of left lateral hemorrhoid.

drawn, and the same amount of the solution injected deep underneath the mass. After waiting about two minutes the pile is

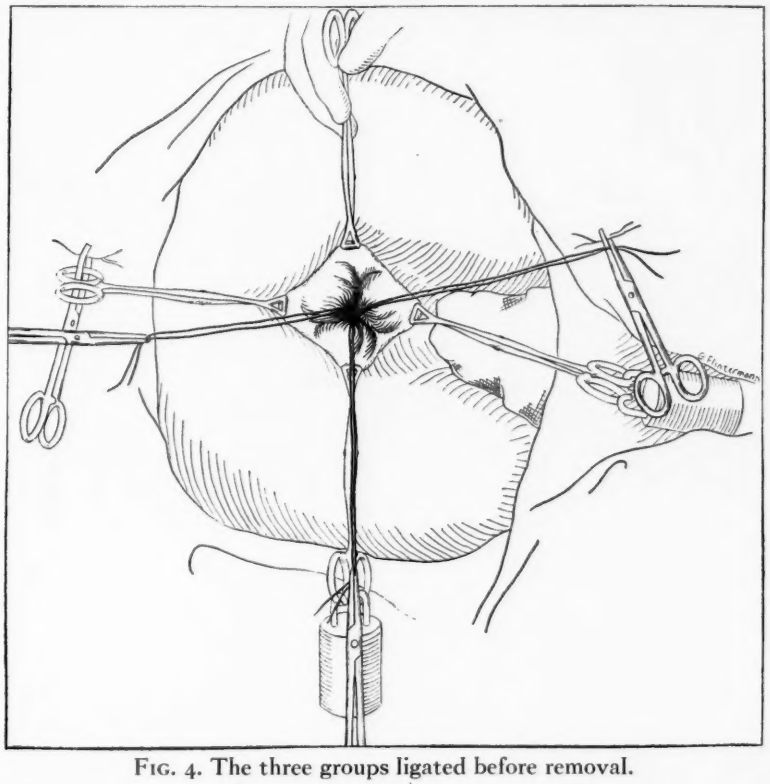

Fig. 4. The three groups ligated before removal.

removed through an incision made through the skin and down to the clot, radial to the anus and extending for about ¼ inch into the skin beyond the tumor. The tissues around the tumor and below it are again injected if necessary when it is dissected out by means of a small-toothed forceps and curved scissors. After the clot is removed, the surgeon should look carefully into the wound for other smaller clots and remove all of them.

The edges of the wound are trimmed back in an elliptical manner to leave a gaping wound. This will heal by granulation from the bottom without any possibility of the edges of the wound turning in and retarding its healing. A ½ inch strip of rubber tissue may be lightly inserted into the wound, and a sterile dressing applied. This is removed in twenty-four hours, and it is not necessary as a general rule to use further drainage. The wound should be seen and dressed daily, and some mild antiseptic powder may be applied, such as thymol iodide, boric acid, or stearate of zinc. The patient immediately after this operation, experiences a keen sense of relief from the removal of the tension caused by the thrombotic mass.

PROLAPSED INTERNAL HEMORRHOIDS

Patients suffering from prolapsing internal hemorrhoids almost all give a history of the usual hemorrhoidal symptoms. These are ordinarily bleeding, pain and protrusion. Hemorrhoids prolapse only after severe straining efforts, or following the passage of a constipated movement, unless they have been of long standing, and gradual inertia of the external sphincter has taken place. Patients suffering from this type of prolapse are often unaware of its occurrence. The pain is due not only to pressure of the thrombi on sensory nerves, but also by the spasmodic contraction of the sphincter muscles on the prolapsed

mass. Sphincter spasm and tenesmus are both extremely painful symptoms.

The prolapse which occurs with thrombosis is accompanied by excruciating, almost unendurable pain, requiring hypodermics of opiates to give sufficient relief so that an examination can be made. The use of hot compresses or sitz-baths, as suggested for the treatment of acute thrombotic hemorrhoids may provide considerable relief. The diagnosis is usually self-evident.

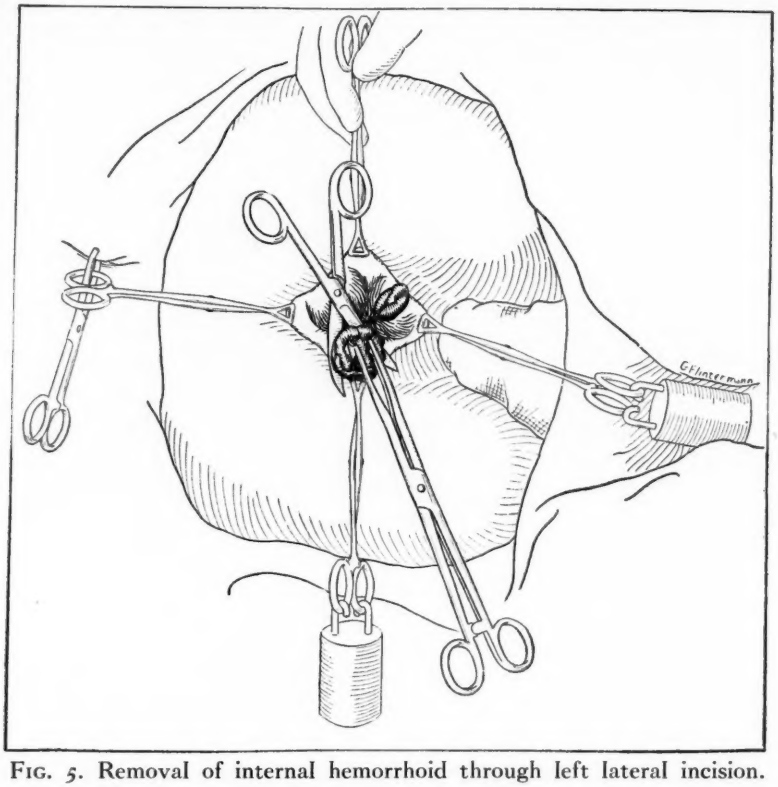

Fig. 5. Removal of internal hemorrhoid through left lateral incision.

Prolapsed internal hemorrhoids which become thrombosed appear as one or more rounded purple or dark tumors, continuous with, or surrounded by the anus. Usually the emergency treatment of any prolapsed condition starts with the reduction of the prolapsus. This is usually impossible without the employment of local, caudal or spinal anesthesia. In personal practice spinal anesthesia has never been found necessary for this procedure.

Operative Treatment under Local or Caudal Anesthesia. The emergency treatment of prolapsed internal hemorrhoids which have become thrombosed, is of course, the excision of the diseased tissue. This predicates a hemorrhoidectomy. Proctologists rarely employ general anesthesia for operations such as this. With the exception of a case where a thrombus has occurred in one or two hemorrhoids, there is no contraindication to—and usually every indication for—an internal and external hemorrhoidectomy.

Where a single hemorrhoid has been thrombotic—after anesthesia has been produced—an elliptical flap of the mucosa is excised and the clots either emerge or are expressed. If a small artery has been cut, the spurting vessel is ligated with No. 1 plain catgut. Venous bleeding is controlled by a touch with the cautery or a pressure bandage.

The author's technique for hemorrhoidectomy is as follows:

After the patient has been relieved of the acute pain by sedation, 3 gr. of phenobarbital are given and a one-quart hot soda bicarbonate enema is administered. One hour after this has been expelled or

siphoned off the patient is ready for surgery. After skin sterilization according to the technique preferred by the surgeon,

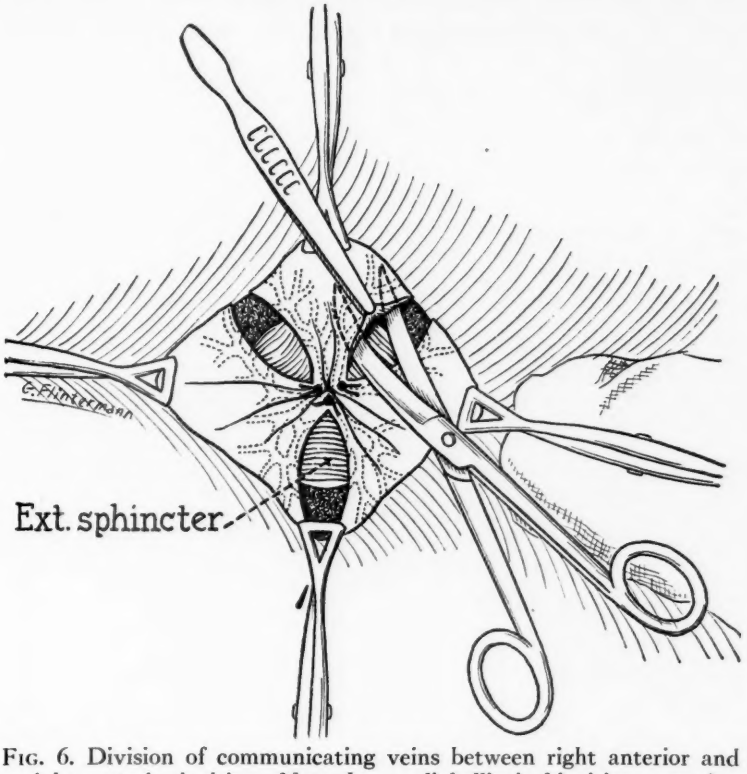

Fig. 6. Division of communicating veins between right anterior and right posterior incisions. Note three radial elliptical incisions exposing external sphincter muscle.

caudal anesthesia is administered. We give 40 c.c. of 2 per cent solution of procaine in Ringer's solution, injected through the caudal hiatus into the caudal canal. If piston pressure indicates that the canal is not filled, sterile water is added until there is considerable resistance to pressure. When the needle is inserted into the caudal canal, aspiration should be performed in order to be certain that the needle has not punctured a vein. If blood appears on aspiration, a vein has been punctured, and the needle should be withdrawn and reinserted. From seven to fifteen minutes is usually required for anesthesia to become complete.

Any form of hemorrhoidectomy which removes only enough mucosa to expose a thrombotic mass and yet allow of its complete removal along with any other varicosed veins can be employed. Our technique is as follows: Triangular or Allis forceps grasp the perianal skin at four equidistant points. Two are placed on the lateral anal edges, one anterior, and one posterior. Since most internal thrombotic hemorrhoids are accompanied by some external thrombosis as well, it may be necessary to place these forceps on the external thrombotic areas. As these are to be excised later, no concern should be felt about this. Traction on these four everting forceps will expose the entire operative field in a way not possible by the employment of specula or retractors. No part of the area is obscured by any part of a speculum or a retractor. The relation of each hemorrhoidal mass to the others can be accurately observed.

Inasmuch as most hemorrhoids occur in three constant areas, they can be removed in three groups, the right anterior, right posterior and left lateral. With the patient lying on the left side the most dependent group would be the left lateral, and this is therefore the first to be removed. The hemorrhoidal mass is grasped at its outer extremity with Hirschman pile forceps, or a

similar instrument, and a blunt-pointed ligature carrier or a small round curved needle, threaded with No. 1 chromic catgut is passed in through the mucous membrane on one side, down to the base of the hemorrhoid, and around to the opposite side in such a manner as to include the upper half of the mucous membrane covering the pile and surrounding all blood vessels underneath. This ligature should be placed just at or above the juncture of the hemorrhoid with normal mucous membrane. It is then firmly tied, thus securely shutting off the blood supply of the hemorrhoid.

The right anterior and the left lateral hemorrhoidal groups are treated in like manner. The ligatures are left long and are held out of place by hemostats. After all ligatures have been placed, the left lateral hemorrhoid is again grasped with the hemorrhoidal forceps and an elliptical flap excised sufficiently large to expose the clots and varicose veins composing the hemorrhoid. Some of these veins and clots may come away with the flap.

All others are carefully dissected out until the sphincter sheath is exposed. Should there be any arterial spurting, usually from the mucosal walls, the hemorrhage is controlled by No. 1 catgut ligatures. As a rule there is no such hemorrhage because of the control of hemorrhage produced by the original three ligatures. The right anterior and right posterior hemorrhoids are excised in the same manner. Care should be used not to excise any more of the normal mucosa membrane overlying the hemorrhoidal mass than is necessary to expose the pathology. When these operative wounds contract they appear to be but slits or "buttonholes." The cut edges are allowed to fall together without suture.

The hypertrophied external skin folds, whether they contain thromboses or not, are excised radial to the anal aperture. All veins between the incisions are undercut beneath the mucous membrane inside, and subcutaneously outside. All of these radial wounds are tapered, so that no cupping occurs. A tapered wound not only drains well but reunites better and prevents edema.

Ten c.c. of 1 per cent diothane solution is injected underneath the incisions and circumanally. This produces a degree of postoperative anesthesia which may last for several days, and is responsible for the comfort and shortened hospital stay of these patients after the usual external or internal hemorrhoidectomy.

A strip of rubber tissue with some analgesic ointment is inserted into the canal and a compression dressing applied. The patient is put on a minimum residue or fluid diet and is allowed to leave his bed within twenty-four hours if necessary.

The usual period of hospitalization runs from three to seven days.

CONCLUSIONS

This technique is simple and effective for the following reasons:

1. It can be performed without general anesthesia.
2. Hemorrhage is controlled before it can occur, by the preliminary ligation.
3. A minimum amount of mucous membrane is removed and the pathology is removed largely by submucous excision.
4. No packing, plugs or tubes are required.
5. There is no diminution of the bowel caliber.
6. The period of hospitalization is minimized.

FRACTURES AND FRACTURE-DISLOCATIONS OF THE SPINE

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THE recognition of fractures of the spine, especially of the milder types, is becoming more general. It also has become a matter of routine to suspect their presence with other types of injury in a fairly regular percentage of cases. This is particularly true of their association with fractures of the os calcis. So it is important to analyze carefully the history of injury. In many hospitals it is becoming routine not only to examine carefully for such a possibility, but to *x*-ray the spine thoroughly to rule out its presence. This is especially important in the group of cases where there is a history of a compression and impaction force, though often the symptoms may be only vaguely suggestive.

On the other hand, the changes which have taken place in transportation—the wide use of the automobile with its ever increasing speed, as well as the more hazardous types of industry—have increased the liability tremendously.

The force causing such fractures is either a quick hyperflexion force, such as results from passing over a dip in the road in an automobile, where the rider receives a jouncing action, or where a compression force is brought to bear on the spine, such as would result from a fall from a height, or from a blow on the head in a fall or in diving in shallow water. In cervical fractures, comminuted fractures, and in fracture-dislocations, twists and lateral force undoubtedly have a direct influence.

Fractures of the spine may be quite mild as to their outcome, as in the simple impacted group, whereas, on the other hand, they may be extremely serious, especially the cervical fractures in the level of the atlas and axis, or in the comminuted and dislocated cases commonly seen in the dorsolumbar level. It is because of the serious nature of these latter mentioned groups that we should continually bend every effort to educate the layman, the foremen on jobs, and especially those whose duty it is to render first aid, such as highway patrol and ambulance men, in the careful handling of all injured people. Probably the most serious risk is in the handling of those injured in the highway automobile accident.

A few simple rules for the handling of accident cases may be stressed:

A. Always handle the injured without twisting or bending the body. In no instance allow a sitting or standing position until an examination has been made.

B. A rigid stretcher is to be used at all times.

C. All seriously injured or suspected patients should be taken immediately to a properly equipped hospital where the treatment is to be instituted, and not first to a police station and next to an emergency hospital, thus losing valuable time in unnecessary handling and examinations.

Upon the admission of the patient to a hospital, a thorough physical examination should be made to determine the general condition and the possibility of other fractures, such as those of the os calcis. The most important part of the examination is in determining the presence of cord or nerve root involvement, since the *x*-ray examination should be guided directly by the findings, and the technician warned accordingly of the risks in the handling of the patient. Very often the approximate level can be determined fairly accurately. It is of the utmost importance that when neurologic symptoms are found, a detailed neurologic examination should be done immediately, before the *x*-ray examination, and the findings recorded.

If it is judged proper, the patient may be carefully moved to the *x*-ray department

for that portion of the examination, but if in the first examination one is suspicious of cord or nerve root injury, the *x*-ray examination should be made in the bed, even if the bed has to be moved to the *x*-ray department. This is more true in cervical fractures, but is equally applicable to cases with symptoms of cord injury at a lower level.

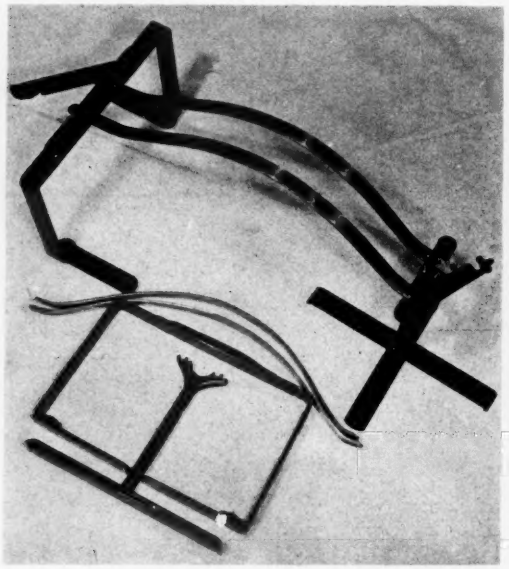

FIG. 1. Photograph of two portable Goldthwait frames, one assembled for use and one taken apart and ready for transportation. These frames may be set on any steady table, such as is found in every kitchen. It is quite as efficient as the hospital type of frame.

Since fractures of the spine frequently occur at more than one level at the same time, the entire spine should be very thoroughly covered by the *x*-ray examination. Careful judgment should be used in the taking of the roentgenograms as to the amount of movement permissible, since not only may the pain be severe, but permanent damage may be done by changing the position of the fragments. The radiologic technicians should be minutely instructed in such technique.

After the fracture has been demonstrated by the roentgenogram—the general condition of the patient permitting—immediate arrangements should be made for the reduction and application of the fixation cast. As in all other types of fracture, as early a reduction as possible is indicated. The earlier done the more easily accomplished. If complications are going to arise, it is much better that the reduction be accomplished first. For instance, in a certain percentage of cases, temporary paralytic ileus develops, and it is just as likely to appear before as after reduction. In a recent case, reduction was delayed because of its presence, and as the condition did not improve over a period of several days, the reduction was done and immediately the condition disappeared. It may be that the condition had about reached its end, or it may be that the

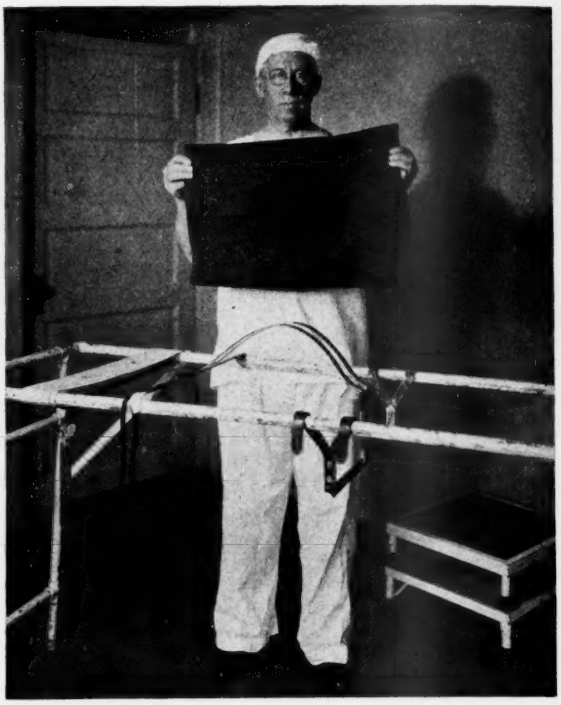

FIG. 2. Method of reduction. Hospital type of Goldthwait frame. This is attached to an ordinary gas-pipe frame. The two curved bars are the important elements. They are bent for each case, in order to bring the highest part of the curve just under the fractured spine, which has been compressed. The bars are made of spring steel, so tempered that they will remould the spine of a heavy man; it is essential that their flexibility be perfect. The felt pad is placed on the bars, to be included in the cast. The latter is applied as the patient lies on the bars after the successful reduction. The split in the felt pad is to relieve the pressure on the spinous processes.

A portable Goldthwait frame is quite satisfactory. The bars are interchangeable with those of the hospital type.

accomplishment of the reduction had something to do with its cessation.

Also, other complications may arise, such as acute colds and pneumonia, which postpone the reduction indefinitely, or even interfere with its accomplishment. Early reductions are definitely more accurate than those done after a delay, and the perfection of reduction is in direct ratio to the time elapsed after the fracture has been received.

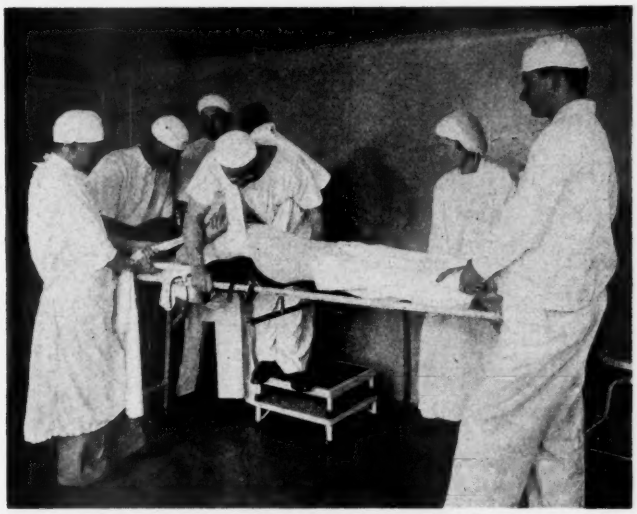

Fig. 3. One of the methods of producing hyperextension. The patient is placed on the Goldthwait frame. He is balanced by one assistant who holds the legs, and by two others who balance the shoulders by means of a folded sheet passing to the opposite axilla. A folded sheet is passed under the body at the level of the fracture and is tied over the shoulders of the operator, who then lifts the spine into the amount of hyperextension necessary to pull out the impaction of the vertebrae. When this is accomplished, the patient is lowered to the bars of the frame and an *x*-ray film is made to note the success of the maneuver and of the moulding of the spine on the frame. If the result is satisfactory, the plaster cast is then applied without further moving the patient.

When all the data have been obtained by the physical examination—necessary laboratory examination including the Queckenstedt test, and the roengenologic examination—a proper analysis will determine the possibilities of manipulative or operative correction procedures. The only immediate operative procedure to be considered is a laminectomy. In those cases with a complete cord severence, resulting in immediate paralysis, laminectomy is not indicated. If cord pressure is proved to be the result of splinters of bone, they might well be removed, but if paralysis comes on slowly it is fairly certain that it is due to cord pressure. Such pressure may be from slight misplacements or narrowing of the canal due to the mechanical kyphos, causing localization of hemorrhage or edema. In all cases where a misplacement could in any way account for the pressure symptoms, the injured should be given the benefit of a manipulative reduction. It is surprising how frequently such symptoms will clear up following a successful manipulative reduction and proper fixation.

In all cases with neurologic symptoms, special precaution must be taken with every stage of the manipulative procedure. A reduction should never be undertaken until the surgeon is satisfied as to the cause of the paralysis, and then manipulation and fixation are planned to suit the individual case.

It is highly important that every hospital accepting emergency work should be properly equipped to handle spinal injuries.

A detailed list follows of all the necessary material and equipment, which in analysis are quite simple:

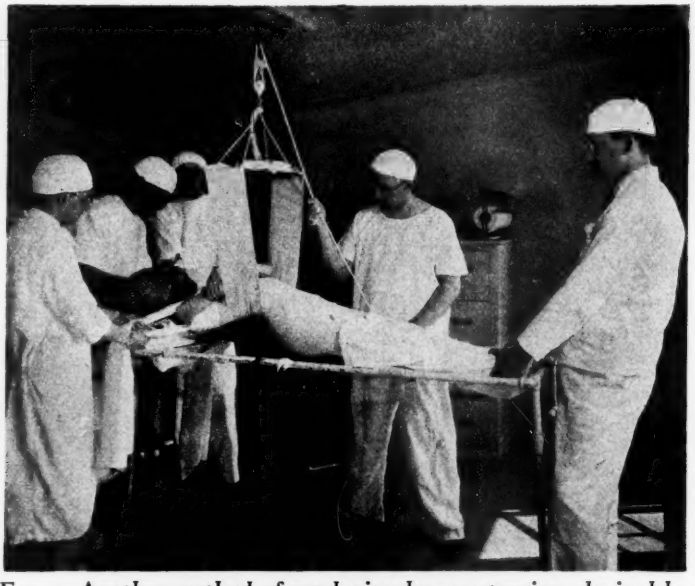

Fig. 4. Another method of producing hyperextension, devised by Dr. John Wright of Pasadena, California. It is easier on the operator in controlling the amount of hyperextension. In other respects it is exactly the same as the method indicated in Figure 3.

1. Stockinet of sizes to fit both slight and stout individuals. Several different widths should be available.

2. Unbleached cotton bandages sufficiently strong to be placed under the stockinet to be used as leaders for pads, for the application of alcohol and powder to the body within the cast.

3. Heavy gray felt, 1 inch thick and not too tightly compressed.

4. Sheet wadding, rolled in widths of about 6 and 8 inches.

5. Plaster bandages, 6 and 8 inch widths.

6. Plaster reinforcements sufficiently long to extend from top to bottom of cast, approximately 20 inches in length, and about 6 inches in width. Each jacket requires about six such reinforcements.

7. Two deep buckets for wetting plasters (plaster bandages to be put in end on for thorough wetting).

8. Knives for trimming cast after application.

9. A hospital cart for transportation of patient to and from the operating room.

10. A Goldthwait frame, with a choice of bars of proper length for the individual case, and of the correct temper for the weight of the patient.

11. A fracture table with shoulder supports, for use in cervical fractures as described later.

12. A hook in the ceiling securely fixed to hold several hundred pounds weight.

13. A hook in the wall at level of height of fracture table, to be used in the correction of cervical fractures.

14. A block and tackle.

15. A strong webbing belt and spreader, so arranged that it can be easily attached to hook in block and tackle.

For the *cervical cases*, the following in addition:

16. A thin, narrow board, to support the body and neck up to the head.

17. A Glisson sling and metal spreader.

18. A spring balance.

19. A portable *x*-ray machine, to be used in the plaster room in all spinal fracture cases.

20. A sufficient number of assistants or nurses to do the job. We find five, in addition to the anesthetizer and surgeon, to be the proper number.

If the diagnosis indicates that reduction is advisable, any fracture of the spine can be properly and accurately reduced with the equipment listed above, and should be accomplished in approximately one hour, counting in the time involved in having one or two sets of check-up roentgenograms made. It has been accomplished within a half hour.

The following detailed description of the procedure is that followed in the most simple type of compressed and impacted fractures, the more complicated cases requiring variations which will be described under their special headings.

PROCEDURE FOR THE ORDINARY DORSOLUMBAR COMPRESSED AND IMPACTED FRACTURE

The patient is anesthetized on the surgical cart. We prefer a preliminary avertin followed by a gas anesthesia. The patient, still on the cart, is placed directly under the hook in the ceiling, to which is attached the block and tackle. The webbing belt is then passed under the affected area and strapped over the spreader, and the spreader is attached to the block and tackle.

An assistant now balances the legs, and each arm is balanced by a separate assistant, as the operator lifts the patient on the sling into a hyperextended position, with the fulcrum at the level of fracture. Depending upon whether there has been a simple compression or a deep impaction, the operator will be guided as to how much force is required to disimpact the fragments. During this maneuver the alignment of the patient is scrupulously maintained. When the disimpaction has been accomplished, the cart is removed while the patient is held up by the sling and balanced by the assistants holding the arms and legs. The Goldthwait frame is now placed under the patient by other assistants, so that when he is let down upon it the high point of the bars of the frame will be exactly at the level of the fracture. The height of the bars has been previously adjusted by the operating surgeon so that when the body rests upon them the spine will so mould itself as to bring the loosened fragments into proper alignment. It is this moulding power of the bars of the Goldthwait frame that is responsible for such perfect reductions.

Next, the large felt pad upon which the patient rests is placed on the top of the bars. This must be 1 inch thick, and as long and as wide as the body of the patient.

A lateral roentgenogram is then made to demonstrate the correction of the alignment, and if it has not been wholly successful the manipulation by hyperextension with the sling and block and tackle is repeated. Rarely has it been necessary to repeat this disimpaction maneuver more than once.

In those cases where there has been compression without impaction or extensive comminution, little or no hyperextension may be necessary, the Goldthwait bars readily accomplishing the reduction with the patient fully relaxed.

When one is satisfied that the reduction is completed, the body is wrapped with a thin layer of sheet wadding, the bony prominences padded with felt a half inch in thickness, and the supporting cast then applied.

The cast should be made so that there is a rigid three point control—the high point of the spine at site of fracture in the back, and at the very top and bottom of the cast in front—and it should fit as snugly as possible about the pelvis.

When the cast is thoroughly set, the patient is removed from the frame by means of the sling and block and tackle, and placed on his side on the transportation cart, the bars of the frame remaining in the cast. The bars are now slid out of the cast, and the cast trimmed about the pelvis and arms for comfort, and to allow care for

nursing purposes. In addition, a window is cut to expose the epigastric area of the abdomen. This was originally done to facilitate abdominal examinations in those cases developing ileus, but it was found most comfortable in the presence of abdominal distention due to gas. It also helps in the after care of the skin within the cast.

The patient is then placed in bed and a pillow is kept under the high level of the lordosis until the cast is dry, to prevent sagging and loss of position of the fragments.

From this time on and during the remainder of the period in bed, there are only a few rules important to observe.

1. Never turn the patient on his face. He may be turned to 80 degrees from the flat of the back for one hour each day on each side, to rest the spine.

2. Each day the entire body within the cast must be given an alcohol rub and powdered. This is accomplished by passing pads tied or sewed to the bandages, leaders having been placed within the stockinet for that purpose, and using a see-saw movement. Great care must be used to pass the pads across the area of fracture where the cast fits most snugly, otherwise a pressure sore may develop at this point. If this appears imminent it is advisable to cut a narrow window, just large enough to release the presure on the tips of the spinous processes, but still not remove the control from the lateral processes. A window 1½ inches wide, and from 4 to 5 inches long has always been sufficient, and in a long series of cases it has not been found necessary in more than a dozen cases.

The patient is kept flat in bed for fourteen to sixteen weeks, or until a roentgenogram shows that the bone repair is sufficiently firm to hold the correction with the superincumbent weight of the body when standing or sitting.

In no other method, where standing has been permitted, has there been such a high percentage of retention of full corrections. If the correction is not maintained, why do a correction?

Check-up roentgenograms are made as soon as the cast is dry. After fourteen weeks, the cast is split on both sides, the patient rolled out, measurements made for a Taylor back brace, and a roentgenogram made. The patient is then returned to the split cast until the back brace is finished.

With the brace on, the patient is stood up, always with heavy shoes to support the feet, and from *that* time on a gradually increasing amount of weight bearing and walking is encouraged until full strength is recovered. These patients gradually increase the distance to about a five mile walk daily, and often pool swimming in addition, together with special pool exercises. They are encouraged to return to duty after approximately seven months from time of accident, and if the reduction has been accurate and well maintained this should be possible without any disability. If disability remains, it is unquestionably due to ligamentous, nerve root, or slight cord injuries, which have been unrecognizable, and they are of low incidence.

In the badly comminuted fractures, a longer time is required to obtain firm bone repair.

Warning: Care must be taken in all fractured spines before manipulative reduction is undertaken, to rule out fractures of the arch, for if present, an entirely different procedure is advised.

This method is recommended because of its simplicity and its accuracy and retention of reduction. The point which speaks loudest for its success is that in the thirteen years it has been used there has been but one change in the procedure, i.e., a variation in the amount of force that may be necessary to produce disimpaction.

It is now recognized that the amount of force necessary may be judged by the appearance of the roentgenogram. In deep impaction much force in hyperextension may be necessary to sufficiently loosen the fragments. However, in the great majority, as little force as was used in the first case done is found to be sufficient, and where impaction is absent, little if any forcible

hyperextension is necessary preliminary to placing patient on the Goldthwait bars for the moulding of the spine.

COMMINUTED FRACTURE DISLOCATIONS

This same technique is followed in fracture dislocations or comminuted fractures of the spine, *with very definite restrictions*. The sling is not used for hyperextension or for lifting the patient. The amount of movement of the spine accomplished in this way is absolutely contraindicated.

The patient is placed very carefully and with as little movement as possible on the previously prepared and padded Goldthwait frame.

Traction and countertraction with the body firmly supported on the bars of the frame is the important feature of the reduction. This is accomplished by traction on the legs against countertraction obtained by two assistants with folded sheets placed under the opposite axilla from which they pull. In this way too great pressure is not placed on the axillary vessels and nerves. This traction should be steady and prolonged, with possibly extra hyperextension to mobilize the fragments slightly, accomplished by lifting the fractured area of the spine with one's arms, or possibly a folded sheet under the level of the fracture.

After what is judged to be sufficient moulding has taken place, lateral and anteroposterior roentgenograms are taken to see what has been accomplished. With complete relaxation under anesthesia it is surprising how much reduction may be obtained. If in the surgeon's opinion, still more correction can be accomplished, further traction may be applied.

A plaster jacket is then applied just as the patient lies on the frame, in the same manner as described in the simple compressed and impacted cases. It is interesting to note the early improvement which takes place in the paralysis, which is always present, and the amount of improvement is in proportion to the correction of bone displacement, provided actual destruction of the cord and nerve roots has not taken place. The edema which occurs in such a contorted cord will be relieved with correction.

It is highly important that in this group of cases especially, a very careful neurologic examination be made and recorded previous to any reduction procedure. In complete severance of the cord, of course, no good can come of following such a procedure, but certainly in partial injuries, further damage to the cord due to hemorrhage and pressure edema can be averted.

The most severe and ticklish type of case to handle is the cervical fracture. It is indeed hard to diagnose cervical fractures from the average roentgenogram. The area is difficult to *x*-ray in the high cases at all times, and especially so when injured. Much help may be obtained from the following symptoms:

1. Pain, local and referred.
2. Tenderness on pressure at level of injury.
3. Muscle spasm with accompanying restriction.
4. Disturbance of posture, or angle of carrying the head.
5. Referred disturbance of skin sensation, especially of the arms.
6. Paralysis, variable, depending on the amount of cord or nerve root involvement.

TREATMENT OF FRACTURES AND DISLOCATIONS OF THE CERVICAL VERTEBRAE

Fractures of the neck are much more serious than those of any other level of the spine because they may result in instant total or partial paralysis; or because of lack of support of surrounding tissues, the liability to further damage by movement at site of fracture by unfortunate handling of the injured before fixation is accomplished.

Rarely do we see neck fractures without some cord or nerve involvement. They occur as a result of a blow on the head, or by falling on the head, and result in either:

Hyperextension fractures, the result of the force having been received with the neck hyperextended, usually resulting in injury to the atlas or axis; or

Flexion fractures, where the force is delivered with the neck flexed, usually resulting in a compressed and impacted fracture of the vertebral body.

It is very difficult at times to get satisfactory *x*-ray films of the atlas and axis, and even more difficult to interpret them. In some instances, when the symptoms are suggestive, even though the roentgenogram is not conclusive, it is advisable to go ahead with the full procedure of reduction and try to prove the presence of a fracture by later roentgenograms, when it is easier to handle the patient in a fixation cast.

The Procedure of Reduction and Application of Fixation Cast for Cervical Fractures. We are indebted to Böhler for the following very clear method of procedure:

Place the anesthetized patient on the table, which is especially fitted with arm supports. Böhler insists on a local anesthetic, since a much more accurate check can be kept on the condition of the patient throughout the procedure.

Next, while the head is held by the operating surgeon, who sits at the head of the table, the supporting board for the head and neck is placed in position. Stockinet is then placed in position, a piece to cover the head, small enough to conform to the neck. A larger stockinet is now placed on the body, extending from the perineum up and covering the entire body and shoulders, to which the head and neck piece is later sewed after the reduction has been accomplished.

Felt pads are then modelled to protect the occiput, chin, forehead, shoulders, and for the jacket portion of the cast, especially about the crest of the ilium, on which the jacket is built to rest.

The shoulder attachments to the table are now set. The Glisson sling is then placed about the chin and occiput and attached to the spreader. To the spreader is attached the spring balance, and this in turn is connected by block and tackle with the hook in the wall at level of the table. The supporting board is now lowered. Traction is then applied by means of the block and tackle, during which time the head is held by the operator, with his fingers palpating the cervical spine. When the force of the traction is sufficient, between 15 and 35 pounds as shown on the spring balance, the operator will feel the reduction take place. If the fracture is the result of a flexion force, as in the compression type of fracture at a lower level, the operator may have to supplement a slight hyperextension force, whereas, if the fracture is the result of a hyperextension force, the operator will supply an added flexion force as the traction is applied. The traction is then slowly let up, and the narrow board pulled up sufficiently to support the head.

A roentgenogram is now made to see the result of the procedure. If satisfactory, the fixation cast is applied. If not, the traction and manipulation must be repeated, as well as the *x*-ray examination.

When the roentgenograms show a satisfactory reduction, the Glisson sling is removed, and with the operating surgeon continuing to support the head, with the supporting board withdrawn, the application of the cast is proceeded with. The stockinet is drawn together and sewed—the head piece to the body piece—the sheet wadding and the felt pads properly placed, and the plaster of Paris applied to include the entire body down to the pelvis. After the necessary trimming the patient is returned to bed.

It will be seen that the responsibility for the success of retaining the reduction rests entirely with the surgeon holding the head during application of the cast.

After-Treatment of Cervical Fractures. Because of the frequency of paralysis, a long period of rest in bed is necessary, and special care must be used to avoid contractures, deformities of the limbs, and the development of bedsores.

The use of splints and traction is helpful, as well as avoidance of the weight of bed coverings. Skin traction is not well borne in paralysis. A neutral position for splinting and traction is suggested to avoid strain.

Roentgenograms should be made sufficiently often to follow the progress in

bone healing, or to detect any change in the position of the fragments. If the latter has occurred, the fixation cast should be removed, reduction repeated, and a new cast applied.

When bone repair is sufficiently solid, the patient should be encouraged to become ambulatory, and as soon as possible the cast is replaced by a leather collar. Heat, massage, and supervised active exercises are then begun.

SPINAL INJURIES OTHER THAN FRACTURES OF THE VERTEBRAL BODIES

The Intervertebral Disc. In many fractures of the spine and other spinal injuries without recognized fractures, the intervertebral disc is injured. This may be recognized at the time of the accident, or later.

In many fractures of the vertebral body, especially in the compressed and impacted group, there is seen in the original *x*-ray film suggestion of disc injury. It may show a narrowing of the normal intervertebral space, or a deformity of either the superior or inferior plate of the vertebral body, a result of the injury to the disc. Later, the narrowing of the space becomes more pronounced, and there may even develop pressure symptoms on the cord, due to pressure from a posterior protrusion of an injured disc. An injury to the ligamentum flavae is also responsible for causing a like pressure.

The diagnosis of such a condition is very specialized and requires putting one of the bland opaque materials into the spinal canal to prove the existence of pressure on the cord. If found, a laminectomy is necessary for the removal of the offending tissue.

The treatment of this condition is rarely an emergency, and should never be undertaken except by one especially trained in such work.

The other less severe spinal fractures are:

1. Fractures of the transverse processes.
2. Fractures of the spinous processes.
3. Fractures of the laminae and facets.

1. The treatment of fractures of the transverse processes is of little moment except that they do, when multiple, cause a prolonged disability. When uncomplicated, they rarely require other than bed treatment, preferably on a hard bed. They may or may not reunite, depending upon the amount of separation, and they may or may not cause a long period of pain. A precautionary measure in the treatment by bed rest, is to relax the tension on the muscles attached to these processes, and since the iliopsoas is one of the chief muscles attached to them, a pillow under the knees to assure relaxation is advisable.

2. Fractures of the spinous processes are of more importance since they may be responsible for deformities, as well as prolonged disability, and are not so rare as we have been led to believe.

They occur most frequently at the base of the cervical or upper dorsal region, either as the result of forced flexion, or by direct muscular action.

Attention is usually drawn to the injury by localized pain with decreased ability to straighten or hyperextend the neck, and frequently by the presence of a sulcus, where there has developed a tear and a separation in the ligamentum nuchae.

The *x*-ray examination will disclose a separated spinous process, which may be drawn downward for a distance of more than the width of the spine, so much so, that frequently it is missed in the roentgenologic examination unless especially looked for.

If the separation and damage of the soft tissues are sufficient to interfere with a proper, erect carriage of the head, an operative repair of the torn ligamentous tissue, with removal of the separated spinous process is advised.

3. Isolated fractures of articular facets are difficult to recognize, due to difficulty in the past of obtaining sufficiently clear roentgenograms of such areas, and also to the fact that congenital anomalies are hard to differentiate. Such roentgenograms should be made at an angle of 45 degrees.

When proved, plaster cast fixation for a period of about ten weeks is advised; a fusion operation is even more satisfactory.

SURFACE DEFECTS OF THE HAND*

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SURFACE deformities of the hand† can usually be successfully repaired with free skin grafts which have given satisfactory results many times where the use of a pedicled flap might have been thought necessary. The close, glove-like fitting of the free graft seems to be superior to the loose, unwieldy pedicle flap, unless, of course, there is the loss of deep substance that requires the thick fat pad of a flap.

FIG. 1. A, widespread superficial burn of hand and arm (also face) treated with gentle debridement and open surgical drainage. B, healed in eleven days because there was no full thickness loss of skin.

Superficial Burns. A fresh burn of the hand can probably best be managed by open surgical drainage, using wet packs or grease gauze, rather than sealing the area as with tannic acid or plaster of Paris. The open method allows early determination of the depth of the loss and movement of the joints, and, if there has been no full

† The repair of tendons and nerves is a separate subject in reconstructive surgery of the hand, and the extensive reports of Koch and Mason may be referred to.

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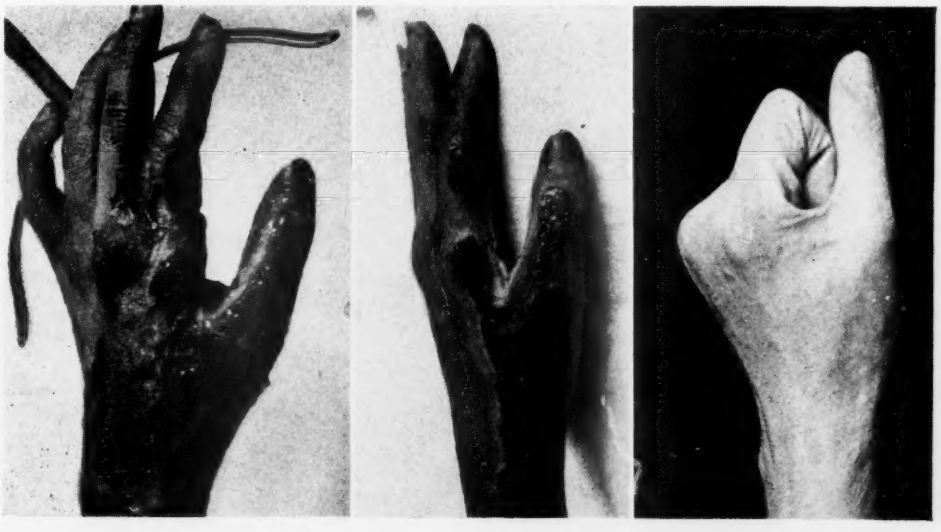
thickness loss of skin, early healing and return to function can usually be obtained by simple debridement of the dead surface and keeping the hand clean and comfortable. If infection does develop in this type of wound, or if the hand is neglected and left out of the position of function, a marked crippling may result from deep fixation of tendons and joints, and possibly from loss of the skin itself from infection. (Fig. 1.)



A B C

Fig. 2. A, one month after laundry mangle injury and burn. B, two days later, after gentle debridement and saline dressings. Operation performed three days later, at which time the granulations were carefully cut away down to a firm base, and the entire area was covered with a single large, thick split graft. C, complete and permanent function shown after four years. (From Brown, in *Ann. Surg.*, 107: 952, 1938.)

Fresh Deep Burns. When the full thickness of the skin has been lost, even over small areas, in such a kinetic region as the hand, the indication for treatment is to restore this loss as completely and as soon as possible. The first treatment should be soap and water cleansing and gentle debridement; then the hand should be wrapped in fine-mesh grease gauze and bandaged. A daily saline soak from one-half hour to an hour and a new dressing with further debridement can then be carried out until the wound is ready for grafting, when it is best to discontinue the use of grease dressings if possible. Active movement should be encouraged during the soak, the fingers should be dressed apart, and the entire hand kept in the position of function. The average burn should be ready for grafting in three weeks, if tendons have not been exposed. Frequently the single application of a split graft may be all that is necessary. If there has been an extensive deep burn, it is often advisable to "dress" the wound with a thick spilt graft as soon as sloughs are separated and the granulations are clean, so that healing may stimulate activity and joint fixation may be limited; later thicker repair can be done if necessary. (Fig. 2.)

In "dressing" the areas with a graft, there will be parts that will regenerate the surface anyway, but the graft is put over the entire area for assurance that the raw areas are covered, and it can later be cut away from the healed surfaces.

Late Unhealed Burns. If losses have been very widespread, there may be repeated ulceration and permanent healing may never occur. The plan of restoration in patients with open wounds is to graft these areas first so that the region will be clean when the hand is opened for correcting the deformity.

Late Deformities Repaired with Free, Thick Split Grafts. Many late deformities can be repaired by carefully dissecting the scar so that complete correction can be obtained with little or no tendon exposure, and then covering the defects with thick split grafts.

FIG. 3. A, widespread deep burns of the dorsum of both hands; corrected by careful dissection of the scar without damage to the tendons and covering each area with one large split graft. B and C, complete permanent function three years later. (From Brown, in *Ann. Surg.*, 107: 952, 1938.)

The split graft is cut one-half to three-fourths the thickness of the skin deep—if possible, in a single piece large enough to cover the entire area. It is sewed on at about normal skin tension with running horsehair sutures all around, usually with the graft overlapping the wound edge, and basted through the center after multiple stab holes are made in the graft for drainage. (Fig. 3.)

If ulcerated areas such as Roentgen ray burns are grafted, the first dressing is kept wet with irrigating tubes incorporated in the dressing, for four days. This plan of wet dressing is open to question, but, for the present, it seems to be the safest for success of the graft, in most contaminated areas. The general details of splinting and dressing are described later under full thickness grafts.

The split graft is rough at first; the fine silk ligatures may work through to the surface, and have to be removed; and many sebaceous collections may have to be emptied by pressure or small incisions. However, the grafts usually clear up so that in six to eight months they cannot be distinguished from a full thickness graft or even normal skin in some instances. (Fig. 2.)

Details of Full Thickness Grafts. Although there seems to be no actual measure of advantage of final function of the full thickness graft, it is often relied upon where widespread clean dissection and removal of the binding scar can be accomplished.

At operation, as on the patient in Figure 4, the scar is very carefully dissected from the underlying tendons; rough, forceful flexion of the wrist (or any other joint area that is being opened) will tear the scar overlying tendons and cause undesirable exposure of the tendons themselves. The scar is removed in layers if necessary, with cross-cuts in small areas to allow stretching. The contracted tendons have to be gradually pulled out so that complete flexion can be obtained if possible. It is even advisable to leave a thin layer of scar on the tendons rather than expose them, if a free graft is to be used, because the graft will not grow on a large area of exposed tendons. When all relaxation pos-

sible has been obtained, the hand is fastened to the wire mesh splint as illustrated, or to an aluminum splint prepared ahead of time, using sterile adhesive or hand is shown in Figure 4D after three weeks' time, with a full take of the graft; it is now ready to be removed from the splint, and function can be started.

Fig. 4. A, complete extension deformity following a widespread full thickness loss of skin, with thumb and fingers definitely out of position of function. B, full restoration of function after careful dissection and coverage with a single full thickness graft. Shown after two years to indicate the permanence of the result. There is complete flexion of the wrist and all carpal joints. C, method of fastening hand to wire (or solid aluminum splint) with sterile adhesive and of application of the graft (three hours' operative time). D, three weeks after operation; full take of graft; arm being taken off splint. E, abdominal defect healed by direct suture. (From Brown, in *Ann. Surg.*, 107: 952, 1938.)

wires through the ends of the fingers. The splint is bent to throw the wrist and fingers as far out of the former contracted position as possible and an accurate pattern of the defect is cut. A full thickness graft is then sutured all around the edges and up on the fingers. (Fig. 4C.) The

If the defect will not open completely at the first attempt because of tendons that are too tight or for fear of exposing too much of them on forced manipulation, then whatever areas are open are grafted, and further freeing and grafting is done subsequently. If tendons are lost and have

to be replaced, or if they are too much exposed, then the advisability of using a thicker pedicle flap must be considered. (Fig. 7.)

The hand in Figure 5A has a complete flexion deformity and webbing of the fingers. Restoration was obtained with one full thickness graft and two subsequent operations for the release of the webs. (Fig. 5B and C.)

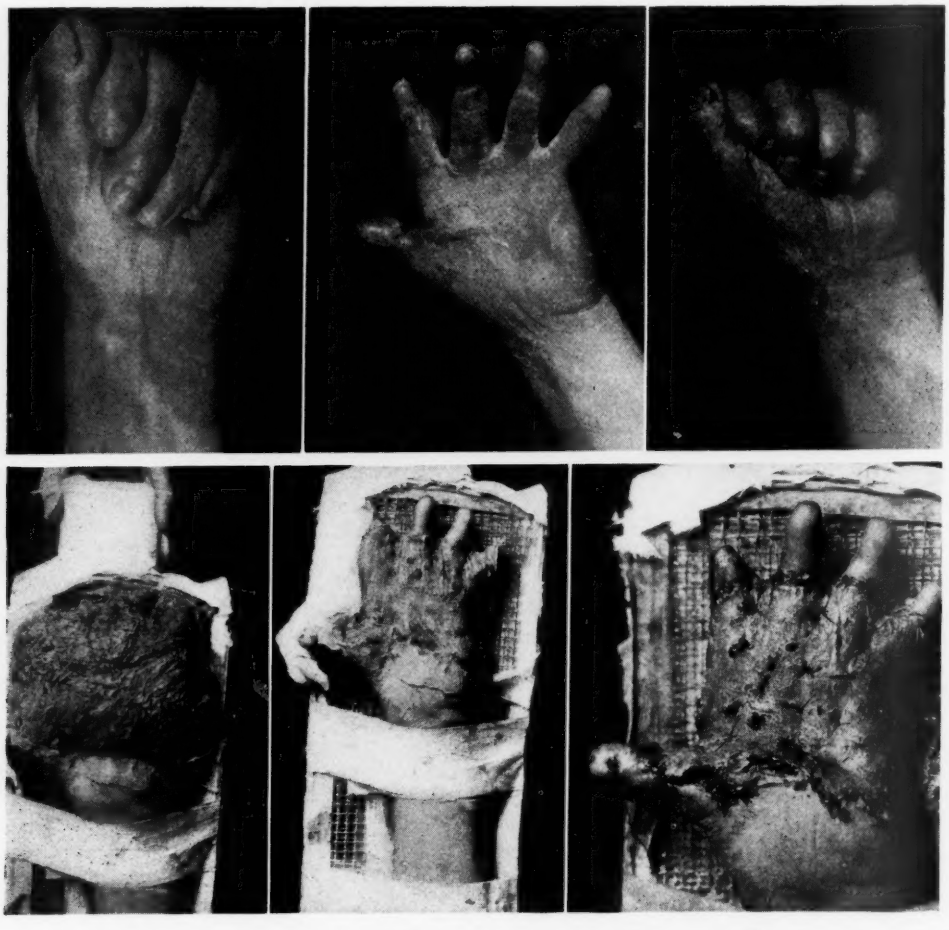


FIG. 5. A, complete flexion deformity and webbing of the fingers several years after a burn. B and C, full function obtained with one full thickness graft and two subsequent procedures to relieve the webbing. D, hand shown at time of first dressing with moulded marine sponge in place. Dorsal surface well padded. E, fine mesh, grease gauze next to the graft which is dry, indicating full take of the graft. F, full take shown with edge sutures; individual mattress sutures through the surface; stab-holes through the graft; and fingers held extended with silver wires through each tip and held to the wire splint. (From Brown, in *Ann. Surg.*, 107: 952, 1938.)

Palmar surface losses can nearly always be repaired with free grafts. Deep losses along the fingers may require thicker flap repair, but full function in one of these is seldom obtained. The contracted single finger, especially in a child, that shows keloid formation, may be one of the hardest deformities to repair, and careful consideration should always be given this apparently simple lesion.

The question of late function of a free graft in the palm might well arise, and, in the answer, the anatomy may be considered. The skin and subcutaneous tissues of the palm are different from those elsewhere; for normal function, the thenar pad is essential, the thumb must be as strong as the fingers and normal position and

movements of the fingers are all-important. When this area is resurfaced, the skin necessarily must come from another part of the body and it always retains its original characteristics and does not change into the type of skin of the sound palm. The grafts shown here have stood up under the patient's requirements for as long as eleven years, but if any work proves to be too strenuous, there is little that can be done other than have the patient wear a glove for protection. In this instance, substituting a pedicle flap would seldom be of benefit because the difference of the skin surface would be the same as in the free graft.

Preparation of Bed for Graft. Figure 6 shows the freeing obtained by removal of the transverse, heavy scars and then careful dissection backward of the palmar flaps without damage of the nerves or complete exposure of the tendons. The edges of the defects are not straight lines but have darts in them to allow maximum replacement of skin. If a straight, narrow graft is put in a child's finger, a possible keloid along the edge may produce deformity. The palmar flaps are utilized in making new interdigital spaces and for part of the finger coverage, and then patterns of the defects are cut in thin sheet lead. (Fig. 6C.) Careful hemostasis is done with pressure and ligatures of white 000 silk.*

Cutting the Graft. The patterns are outlined on the inner side of the thigh and an incision is made just through the skin. (Fig. 6F.) Elevation of the full thickness of the skin is then accomplished, using small forceps or gauze traction on the graft and some countertraction on the edges of the donor area to prevent any subcutaneous fat from adhering to the graft. Some small particles may persist which may be removed with scissors later—if these would retain their viability, they would be of great advantage. (Fig. 6G and H.)

Application of Graft. For a successful correction in one operation, it is necessary that the entire deformity be opened and the hand maintained in complete correction during the period of healing of the graft. This point is almost as important when a pedicle flap is being employed and will be referred to later in Figure 7. The hand is fastened to a wire or aluminum splint with sterile adhesive or wires through the finger pads with the fingers extended, and can then be handled much more easily. The graft is sewed accurately into place all around the edges in order to favor obtaining primary union; where edges are too loose to allow a normal stretch of the graft, reefing sutures may be taken to pull the edges back away from the defect. The tension with which the graft is sewed on is best described as normal skin tension, that is, not pulled tightly like a drumhead, or left so loose that it may wrinkle. (Fig. 6D.) If the graft is larger, it is held down to the bed with additional mattress sutures through the surface. (Fig. 5F.)

Dressing the Graft. A few drainage holes are put through the graft and one layer of fine mesh, greased gauze (5 per cent scarlet red, xeroform or zinc oxide) is placed, very smoothly, next to the graft. Over this one or two gauze flats are placed and soft mechanics' waste is packed carefully between the fingers. Over this, more of the soft fluffed mechanics' waste or a soft, bleached, "wool-form" sea sponge is placed and bandaged firmly in place. A board splint is added for stability and the ends of the fingers are left visible. Figure 5D, E and F shows a hand at the time of the first dressing, done eight days after operation. There is a full take of the graft with no sign of infection, but dressings must be maintained for two weeks longer, using wet applications if inflammation should occur, and otherwise continuing with the greased gauze. The sutures can be removed at the first or later dressings, and there may be an apparent delay in healing because so

* All possible skin is saved and utilized in making these repairs, and flaps may be shifted some distance, but the so-called z-plastic, in which scar webs and bands are entirely depended on to obtain relaxation and function, has not been relied on in any patient in this series.

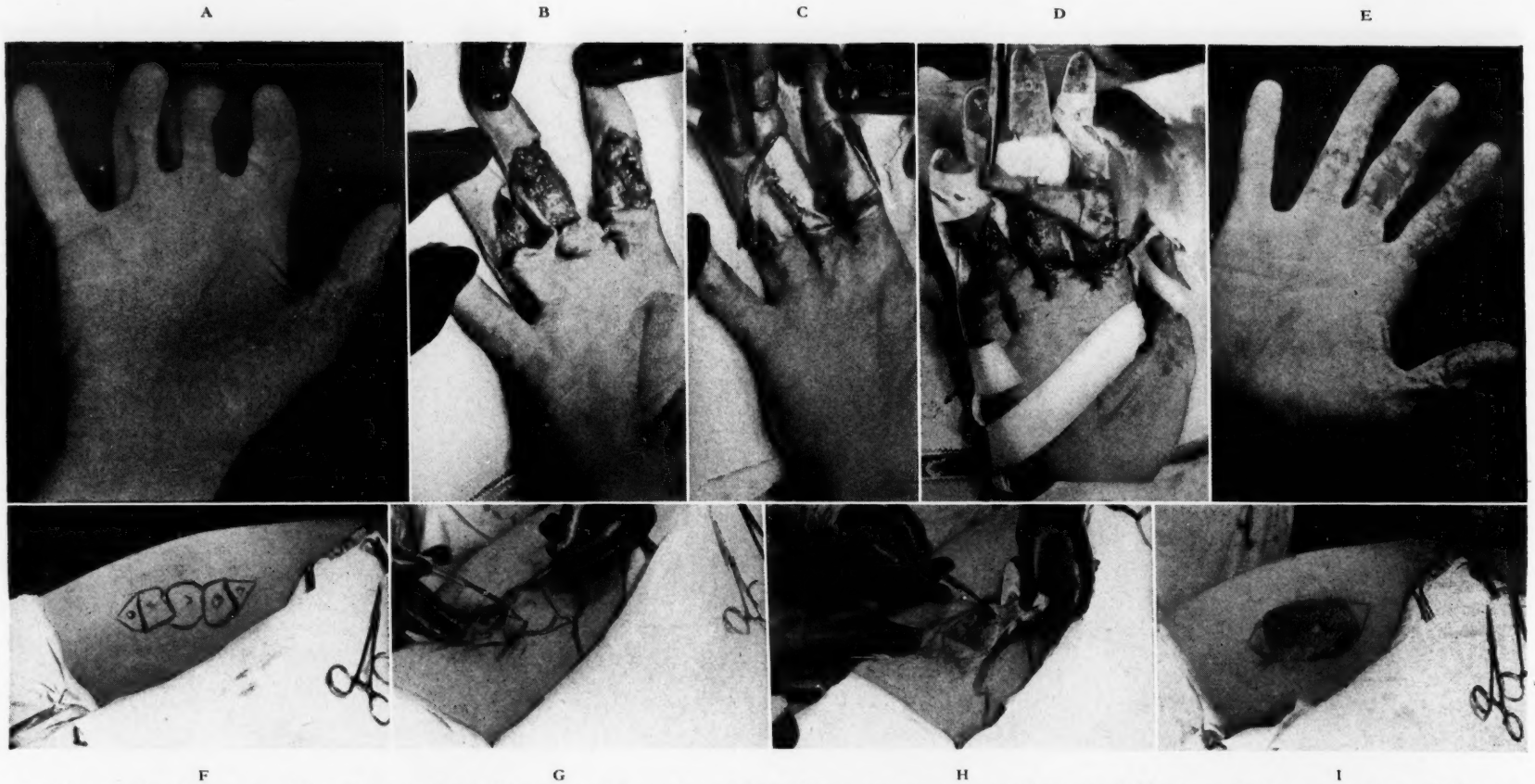


FIG. 6. A, flexion deformity of fourteen years' standing. B, careful opening without damage to nerves or tendons; careful hemostasis; fingers can be straightened. C, the interdigital spaces have been made out of the contracted palmar skin. Lead patterns have been cut of all three defects. D, the graft is sewed accurately all around the edges of the separate defects, and mattress sutures are put through the surface if necessary. E, result three months later. Patient satisfied with function, which is apparently normal. F, the patterns have been traced and outlined through the skin of the inner part of the thigh. G and H, the full thickness of the skin is raised with as little damage as possible, using fine forceps and gauze for holding. No fat is taken up on the graft. I, the graft is free and the resultant wound can be sutured or covered with a split graft from an adjacent area. (From Brown, in *Ann. Surg.*, 107: 952, 1938.)

much of the surrounding, heavily keratinized skin comes away.

The splint is usually maintained for three weeks and then movements are gradually restored. This long fixation, which is primarily for the graft, helps the tendon lengthening also, but it does not do joint movement any good. If there is tendency for contraction after this period, the patient is usually allowed to go about his activities during the day, and at night the dorsal splint is reapplied, using either an aluminum one or a simple one made of wood and held on with adhesive.

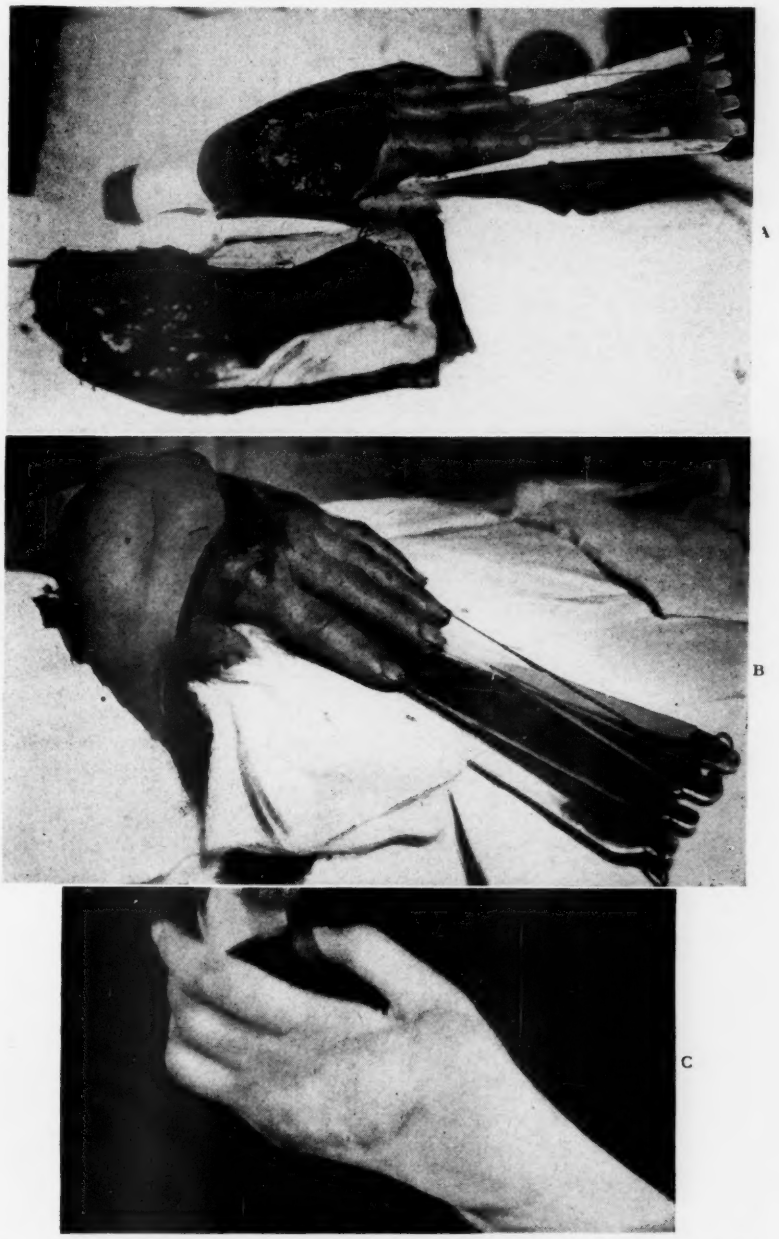


Fig. 7. A and B, shotgun wound of hand with repair by a direct pedicle flap from the abdomen. Hand splinted to give traction for the fingers, and thumb rotated. Same splint used after hand is detached to obtain joint motion and maintain traction. A small wound of entry on the palmar surface was left to close itself. C, result is a hand that is far superior to any prosthesis that might be devised. (From Brown, in *Ann. Surg.*, 107: 952, 1938.)

Roentgen Ray Burns. In repairing Roentgen ray burns, wide excision and immediate grafting with thick split skin grafts will give the most consistently good results. If ulceration is present, or if there is bone or tendon exposed in the fingers, amputations may have to be performed, or a pocket flap from the thigh or abdomen resorted to, but, with the promise of success by early widespread free skin grafting, most patients should fall short of this degree of neglect.

There have been so many failures with immediate free grafting of Roentgen ray burns that many surgeons prefer to excise the lesion first and then later graft a fresh granulating bed. There is, also, serious argument against immediate grafting or application of flaps in any patient with a history of repeated infection or evidence of deep inflammation about the area. These areas should probably all be excised first, and repaired later, to avoid as far as possible, serious crippling infection. The full take of an immediate free full thickness graft on a Roentgen ray burn area is so questionable that it is seldom employed.

Complete Amputation of Finger Tips. It is thought that where there has been a clean amputation of a finger tip, immediate suture should be performed if possible. Crushing losses are not so likely to give good results, and immediate free grafts can be utilized or a pad supplied later by a simple flap from the palm.

Wringer and Other Laundry Machine Injuries. Fairly frequent injuries are seen from catching the hand in electric wringers, and there is usually a large flap torn away with its base distal; there is seldom any tendon or bone damage, and, in a child, the tear may not occur until the arm has come between the rollers.

Many of these cases can be repaired by immediate resuture, and, if it is possible to determine that viability of part of the flap is lost, this can be trimmed away and an immediate free graft applied. If a large flap is entirely off but still clean, it may be prepared as a free graft and used.

Other laundry injuries may have tendon, joint or bone damage, so that pedicle flap repairs become necessary.

Pedicle Flap Repairs of the Hand. There are definite indications for the use of thick pedicle flaps in hand repairs, such as: deep Roentgen ray burns of the dorsum; gunshot wounds; any deep wound that exposes too much tendon, bone or joint; or any late repair that will subsequently need work on tendon or bone and which could not be accomplished with just a free graft restoration of the surface. A broad or double pedicle can nearly always be arranged so that the flap does not have to be delayed.

Probably as many pitfalls occur in the use of flaps as in free grafts, and patients are frequently seen with inadequate flaps, bunched up in a pad on the hand, only replacing part of the deformity.

One of the necessary uses of a flap is illustrated in the gunshot wound in Figure 7A. Amputation had been considered, but it was suggested that at least an attempt might be made to save the hand. Accordingly, after eight days of cleaning the area, a direct flap from the right lower quadrant was sewed in place. The result (Fig. 7C) is a hand that is useful in all housework, far superior to any artificial one, and superior to any possible result that could have been obtained with a free skin graft.

Occupational and Physical Therapy. Following surface repairs in which there has been no deep involvement, if a good result can be obtained and the patient is fairly interested in his recovery, very little else need be done about his rehabilitation. Children usually work out their own problems, but if much joint stiffness has developed, considerable difficulty may be experienced in getting it out of the metacarpophalangeal joints, especially in women who are not likely to need this joint completely flexed. Simple work in the home with the early use of rubber sponge exercise in closing the hand, and such grosser movements as sweeping, shoveling, etc., may quickly loosen the joints. Manipulation to

swing thumbs around into place may be done frequently, but forced manipulation of these joints rarely produces anything but more stiffness. Elastic traction and rotation of the thumb, as illustrated in Figure 7 and as advocated by Koch and Mason for rehabilitation in deeper repairs, will produce the quickest freeing of joint fixation. The finer movements of the interossei and lumbricals can be greatly stimulated by occupational therapy, and many excellent results may be obtained. Secondary operative procedures on the metacarpophalangeal joints may occasionally be of benefit and very badly dislocated phalangeal joints may be resected or an attempt at arthroplasty instituted, but the indications for this last procedure are very infrequent.

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EMERGENCY TREATMENT OF FRACTURES AND FRACTURE-DISLOCATIONS OF THE ANKLE

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WHEN one considers the relatively high incidence of fractures about the ankle joint and the extreme degree of disability and dysfunction subsequent to malunion, injuries of this region assume a major importance. Too often fractures in this area are regarded as "simple fractures"; on the contrary a higher number eventuate in malunion or dysfunction than is commensurate with the type of injury. If these fractures are given due consideration and adequate treatment, the percentage of disability can be materially reduced.

It should be emphasized that fractures and fracture dislocations about the ankle are emergencies and should be treated as such. Immediate reduction and immobilization are desirable; restoration to proper anatomic position is considerably less difficult, maintenance of reduction easier and the end results commensurately better. If reduction is delayed for twenty-four to forty-eight hours, swelling and fixation of the soft tissues make reduction a much more difficult problem.

It is an old axiom in the treatment of fractures, particularly those adjacent to or involving joints, that future function depends upon the approach to anatomic reduction. A study of end results of fractures of the ankle will verify the accuracy of this statement. With the entire weight of the body transmitted through this joint, the closely fitting articular surfaces necessitate accurate reposition for maximum efficiency. After union has partially or completely occurred, further closed manipulation is usually inadequate and may be disastrous; thus, it behooves one to secure accurate reduction of fresh fractures followed by frequent observation to ascertain that the position of the fragments remains unchanged.

Roentgenographic examination of all acute traumatic injuries of the ankle is imperative: first, to differentiate between sprains and fractures; second, in obvious fractures to determine accurately the type of fracture and the true status of the fragments.

For purposes of discussion, fractures about the ankle will be classified as follows: (1) Monomalleolar—including the external and internal malleoli and fractures of the anterior and posterior margins of the tibia. (2) Bimalleolar or Pott's fractures. (3) Trimalleolar or Cotton's fractures. (4) Comminuted fractures of the articular surfaces. (5) Compound fracture-dislocations. (6) Fractures of the astragalus. (7) Dislocations of the astragalus.

MONOMALLEOLAR FRACTURES

The simplest fracture about the ankle joint is a fracture of the external malleolus without displacement. Usually weight bearing can be begun in a snugly fitting walking cast as soon as the reaction from the acute injury has subsided. Too early weight bearing without support should not be encouraged.

Fractures of the external malleolus or lower third of the fibula with lateral displacement of the astragalus from an intact internal malleolus are accompanied by a rupture of the deltoid ligament. This is a much more serious injury than is generally recognized. Because the internal anchorage normally afforded by the deltoid ligament has been lost with improper treatment, a valgus deformity with widening of the

ankle mortice is not uncommon. The foot and ankle should be immobilized as for a Pott's fracture in a snugly fitting cast. As a rule, weight bearing should not be permitted until all reaction has subsided and a second well-fitting walking cast has been applied. The subsequent period of protection should be somewhat longer than for the ordinary Pott's fracture.

Fracture of the anterior margin of the tibia is relatively rare in comparison with other fractures about the ankle, usually being the result of forceful dorsiflexion of the foot. Since the small fragment of bone involves a minimal portion of the articular surface of the tibia, reduction can usually be accomplished satisfactorily by forceful plantar flexion of the foot with direct pressure on the loose fragment. Immobilization is maintained with the foot in slight plantar flexion until the fragment is solidly united. Rarely the fragment may involve a sufficient portion of the articular surface to necessitate open reduction, accurate reposition of the fragment, and internal fixation by a stainless steel screw or nail.

Isolated fractures of the posterior margin of the tibia are uncommon; the loose fragment which usually consists of only a small chip from the posterior articular surface can be replaced by dorsiflexion of the ankle alone. Immobilization is continued in this position. A fragment large enough to involve a large portion of the articular surface is usually associated with a Cotton's fracture.

Fractures of the internal malleolus or adduction fractures appear to be relatively simple injuries since the displacement is usually of a minor degree. Reposition, however, is much more difficult than it would seem. If these fractures are not anatomically replaced and properly immobilized, nonunion is frequent, and once nonunion is established the problem becomes increasingly difficult. Prior to a fibrous union the internal malleolus is practically a loose fragment except for its attachment to the deltoid ligament and little blood is derived from this source. Consequently, the fragment undergoes aseptic necrosis from lack of blood supply, the bone becoming sclerotic and chalky. Such a status is not conducive to reëstablishment of an osseous union even after open reduction, accurate reposition and the insertion of a graft or screw or a combination of the two; in several cases after a bone grafting operation, aseptic necrosis with persistent nonunion and disability continued, eventually necessitating removal of the internal malleolus and plication of the deltoid ligament. To avoid these complications, if the fracture cannot be properly replaced by conservative means, open reduction and internal fixation of the acute fracture are appropriate. The few disadvantages of open reduction are more than compensated for by the exact anatomic reposition.

BIMALLEOLAR FRACTURES

Bimalleolar, or so-called Pott's fracture, is the result of a force whereby the leg is fixed and the foot externally rotated and abducted; the astragalus is twisted in the ankle mortice, producing an oblique fracture of the lower end of the fibula. If the inferior tibiofibular ligament is stronger than the bone, the continued action of this force either ruptures the deltoid ligament or fractures the internal malleolus. The foot and the lower fragment of the fibula are as a rule displaced laterally on the leg and externally rotated with varying degrees of posterior displacement; the astragalus is displaced to the same degree as the fibula. This type of fracture will be referred to subsequently as the eversion type of Pott's fracture.

In contrast to the above fracture an abduction force alone wherein the foot is everted and the leg maintained in a fixed position results in a fracture of the medial malleolus or tear of the deltoid ligament with a fracture of the fibula at or just below the level of the ankle joint.

Adduction and internal rotation of the foot on the leg will produce a fracture of the fibula at approximately the level of the ankle joint or a tear of the lateral ligament

and, if the force is continued, a fracture of the internal malleolus of the ankle. The type of displacement is exactly opposite to the eversion type of Pott's fracture, although not as extreme in degree as a rule.

Another type of injury, which is relatively uncommon, is diastasis of the distal tibiofibular joint, usually associated with a fracture of the internal malleolus, or less commonly, with a rupture of the deltoid ligament. This fracture is the result of a combined abduction and external rotation force with the leg maintained in a fixed position. Since the distal tibiofibular liga-

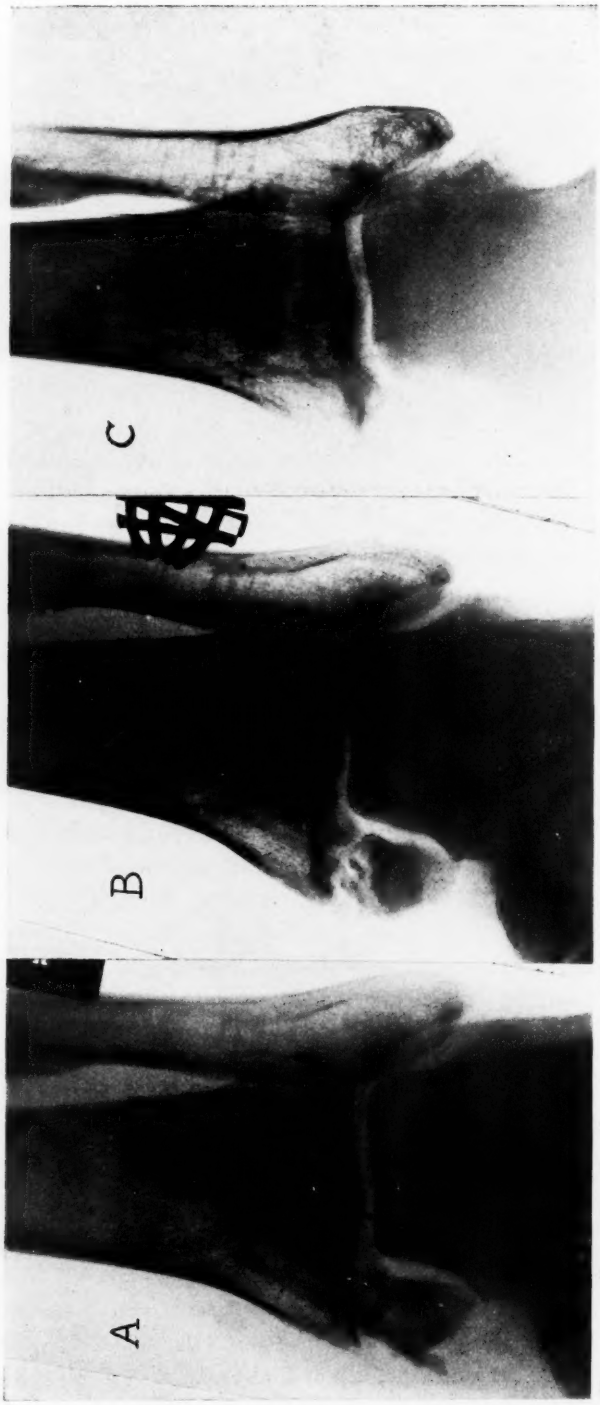

FIG. 1. A, three months after bone grafting procedure for nonunion of internal malleolus. B, one year postoperative, nonunion is still present despite an apparently efficient technical procedure. C, due to continued disability, the internal malleolus, an aseptic sequestrum, was removed; the deltoid ligament was plicated to reëstablish normal stability on the medial side of the ankle.

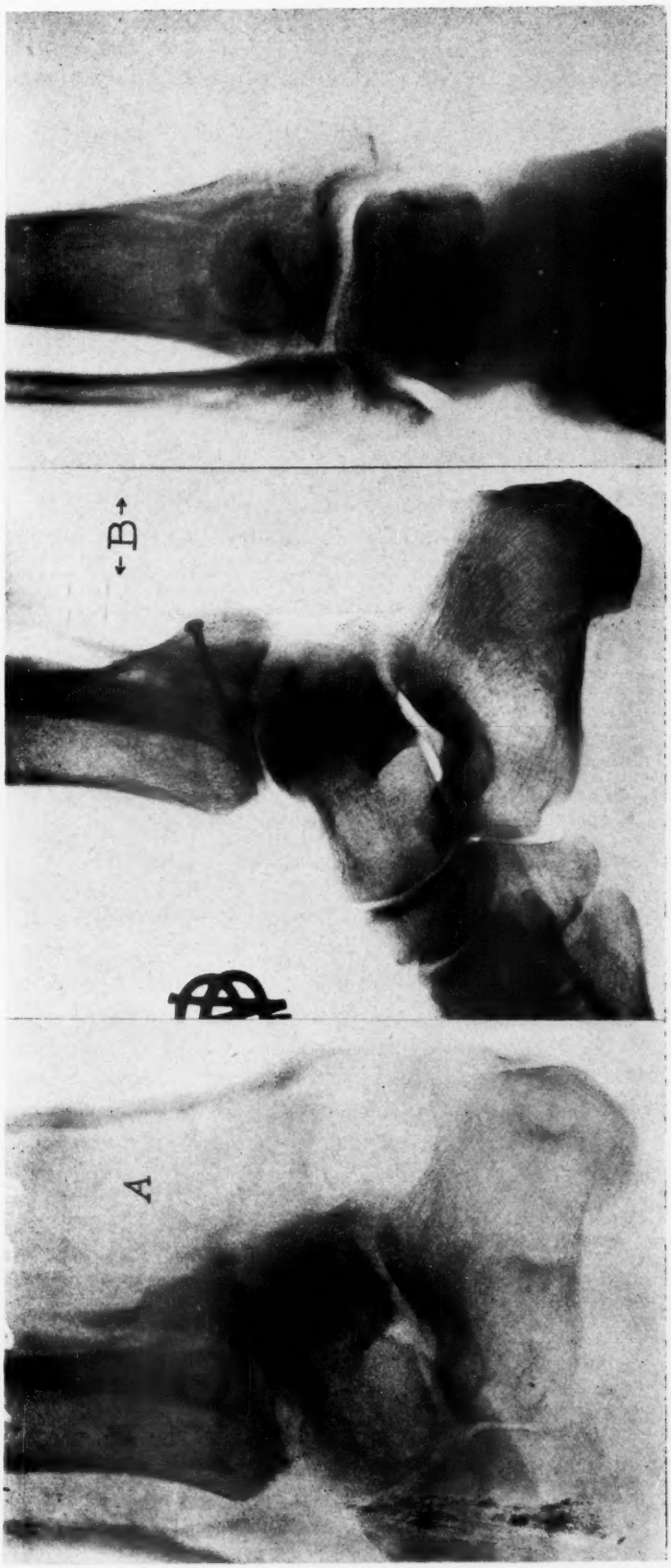

Fig. 2. A, trimalleolar fracture of the ankle with recurrence of the deformity in the cast. B, satisfactory reposition of the fragments after open reduction and internal fixation.

ment is relatively stronger than the bone, fractures are much more common than diastasis.

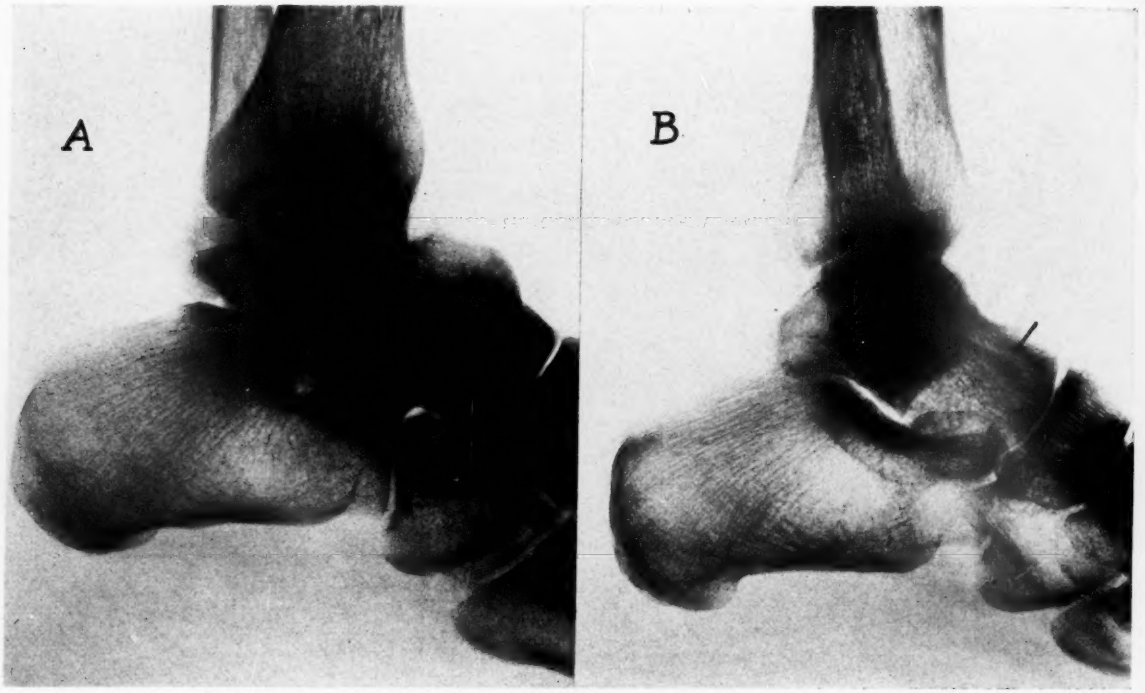

FIG. 3. A, fracture through the neck of the astragalus with complete dislocation of the astragaloscaphoid joint. The distal fragment was rotated 180 degrees. B, one year after open reduction and internal fixation by a homogenous bone peg.

Pott's Eversion Fracture. Since both malleoli are bound to the tarsus, their displacement is of the same degree as the astragalus; thus, the foot, astragalus and both malleolar fragments may be considered as one unit which must be restored to its proper relationship with the proximal fragments of the tibia and fibula.

The movements necessary for reduction of the Pott's eversion fracture are the reverse of the forces which produce it.

Immobilization is instituted by a snugly fitting plaster boot cast which maintains the foot in slight equinus and marked inversion or varus. This is wiser than the immediate use of a walking cast; early weight bearing should be sacrificed always in favor of a positive maintenance of reduction. While early weight bearing is theoretically desirable, practically, it is preferable to wait three or four weeks until the fracture has partially solidified, apply a new walking cast and then institute weight bearing. Many cases in which initial reduction was satisfactory have lost reduction by weight bearing in a cast that has become loose as the swelling of the soft tissues subsided. Over-zealous patients or inexperienced surgeons who ignore this fact open the way for treatment of malunion; if the fracture is reduced properly, and maintained, satisfactory function will eventuate without early weight bearing. On the other hand, walking after partial union of the fracture is a convenience to the patient and is also of therapeutic value, being a means of preventing osteoporosis, possibly promoting an earlier union of the fracture, and lessening the length of convalescence following removal of the cast. Restoration of normal motion in the ankle and tarsal joints is secured more easily in patients who have walked than in those who have been immobilized without weight bearing.

If union has progressed satisfactorily ten weeks after the injury, an ankle brace with an inner T-strap to prevent eversion of the

foot is fitted. An arch support of leather and cork or steel is also worn inside the shoe to insure further slight inversion of the foot. The brace should hold the joint rigid for one month before motion is allowed in the ankle and should be worn thereafter for an additional two months. Use of the arch support may be continued for four to six months.

In elderly individuals or patients with extreme osteoporosis of the foot, physical therapy may expedite early active motion and aid in eradication of the swelling and edema of the foot following active weight bearing.

Pott's Inversion Fracture. The maneuvers necessary for reduction of a Pott's inversion fracture are considerably less forceful than those for the opposite type, though none the less exacting. Immobilization is maintained with the foot in neutral position, i.e., the foot at right angles to the leg and without inversion or eversion; eversion of the foot is not desirable and inversion of the foot tends to reproduce the original deformity. The subsequent aftertreatment is similar to that for the Pott's eversion fracture with the exception that the inner T-strap is omitted from the brace and the arch support is usually unnecessary.

Diastasis of Tibiofibular Joint. Diastasis of the lower tibiofibular articulation with fracture of the internal malleolus or rupture of the internal lateral ligament is a serious injury since maintenance of the proper apposition of the tibia and fibula is quite difficult by conservative means; even slight displacement of the fibula from the tibia widens the ankle mortice and allows an undesirable degree of laxity of the astragalus. This slight disturbance of the normal anatomy is sufficient to induce a traumatic arthritis. If forceful inversion of the foot and a snugly fitting cast are not ample to maintain proper relations between the tibia and fibula, some type of internal fixation is obviously desirable. This is most easily accomplished by a lateral incision over the lower portion of the fibula and the insertion of a vitallium screw through the shaft of the fibula into the tibia.

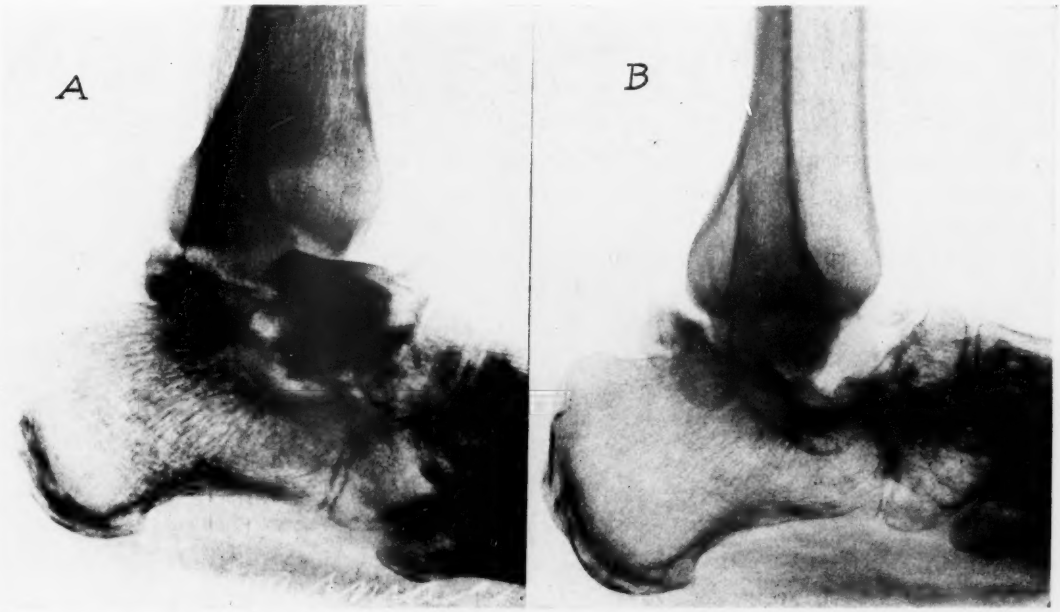

Fig. 4. A, compound infected fracture of the astragalus; the remaining fragments are sequestra. B, after astragalectomy; infection precluded dissection necessary for complete backward displacement of the foot on the tibia.

TRIMALLEOLAR FRACTURES

Trimalleolar, or so-called Cotton's fractures, consist of a Pott's eversion fracture, as described above, with an additional

fracture of the posterior margin of the tibia. From a practical viewpoint, small chip fractures which do not involve the articular surface, or involve only a very small amount of the articular surface of the tibia, are not regarded as true trimalleolar fractures. Their treatment is similar to that of a Pott's fracture, since by the maneuver for a Pott's fracture, with forceful dorsiflexion of the foot, the small chip fragment is pulled down into proper position with the tibia by the posterior capsule and ligament. Further, since it does not involve the articular surface, or only a minimal amount, the possibility of an incongruous articulation need not be considered.

The true trimalleolar fracture which does involve a considerable portion of the articular surface is obviously a much more serious problem than an ordinary Pott's fracture. Here, not only must the relations be restored as for a Pott's fracture, but also the fragment of the tibia must be accurately or anatomically replaced and maintained in position to restore the articular surface of the tibia and provide a smooth surface for weight bearing and motion. This is a very difficult task, if the posterior fragment includes as much as one-third of the articular surface of the tibia.

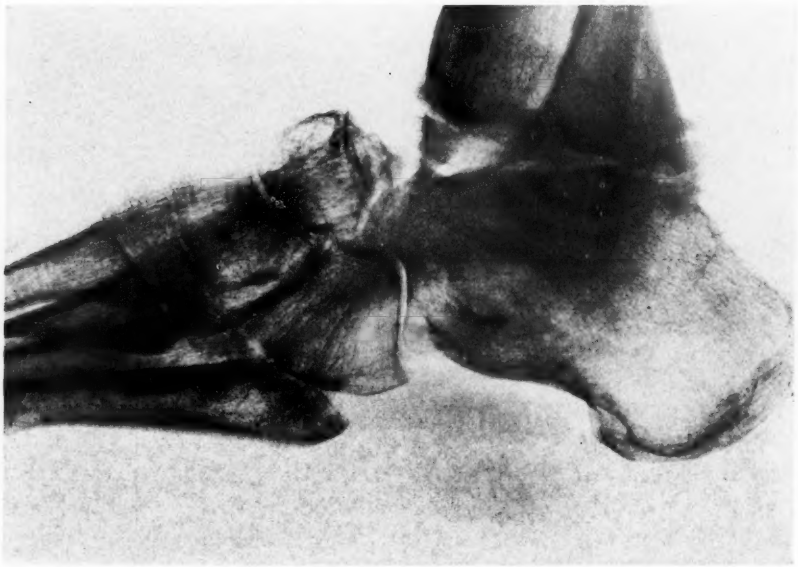

Fig. 5. End result after astragalectomy twenty-five years previously for comminuted fracture of the astragalus. No pain, good weight bearing position and sufficient motion for a normal gait despite lack of backward displacement and proliferative changes about the articulation. Such a result is the exception rather than the rule.

In trimalleolar fractures, if the posterior fragment of the tibia is large, the distal unit is not only displaced and rotated laterally and posteriorly but proximally as well. The maneuver for correction of this deformity is as follows: Traction is exerted in a distal direction to correct the proximal displacement of the astragalus and the fragment of the tibia which lies on the posterior surface of the astragalus; forward traction is then exerted and the foot simultaneously inverted, all the while maintaining the foot in equinus. If the fracture of the tibia includes only the posterior margin, the foot may be dorsiflexed to the neutral position. This will tend to bring the fragment down into normal relationship. If, however, the fracture involves one-third or more of the tibial plafond, the foot cannot be locked in dorsiflexion. When this maneuver is attempted, the posterior dislocation of the foot recurs from lack of support posteriorly. On the contrary, the foot must be left in partial or complete

equinus to prevent this occurrence. Postoperative roentegenograms may show satisfactory position in both views, only to show recurrence of the posterior dislocation after application of the cast, if the foot is not continually maintained in equinus with slight forward traction during the application of the cast.

In preference to this method of treatment, some authors use temporary immobilization in a splint with skeletal traction, the pin or wire being placed through the os calcis; after partial union, if the position is satisfactory, immobilization is instituted with a cast.

Even with satisfactory reduction, frequent roentgenograms should be made at intervals of one, two and three weeks to be certain that reduction is maintained. If there is recurrence of the deformity and the first procedure was carried out efficiently, further manipulation and reduction may be followed by a second recurrence of displacement. In view of the serious disability which follows malunion of a Cotton's fracture with posterior displacement of the astragalus, it is probably better to take a positive attitude and resort to open reduction, certainly after a second manipulation has failed, rather than delay until correction of deformity with preservation of a painless movable ankle is impossible. Experience has shown that once malunion is established, attempts at reducrion and maintenance of a movable ankle result in a high percentage of failures; either the posterior fragment of the tibia cannot be brought downward into proper position, or if this is accomplished, the incident trauma results in degenerative changes of the articular surfaces and traumatic arthritis. Fusion is usually the final solution.

When open reduction is indicated, only the posterior fragment of the tibia, as a rule, is exposed. After proper anatomic reposition, the fragment is fixed by a metal nail or screw. Thereafter, reduction is accomplished as for a Pott's fracture and subsequent after-treatment carried out as described previously.

COMMINUTED FRACTURES OF THE ARTICULAR SURFACE

"Explosion fractures," wherein the articular surface of the tibia and the external malleolus of the ankle joint are extremely comminuted, are the result of a downward thrust of the leg upon the ankle joint. Such injuries may be the result of a fall from a height, and may or may not be compound. The readjustment of the comminuted fractures to as near anatomic position as possible is as a rule an individual problem; the principles enumerated above, however, are useful and applicable to this fracture. In general, immediate immobilization in a cast which extends from the groin to the toes with the knee flexed, is preferable to suspension of the extremity in a Hodgin's splint with skeletal traction exerted on the distal fragment by a pin passed through the os calcis. Motion at the fracture site is immediately eliminated, swelling and edema reduced to a minimum. Incongruity of the articular surfaces following such a fracture is the rule rather than the exception. A spontaneous fusion of the ankle in a good weight bearing position can be considered a very satisfactory result for such a fracture.

COMPOUND FRACTURE-DISLOCATIONS OF THE ANKLE

Approximately 95 per cent of fractures of the ankle are the result of indirect forces, the other 5 per cent being from direct force. Compound fractures are not uncommon in either group. The history and examination of the fracture should reveal the following information: The period of time which has elapsed since the fracture; whether the fracture is compound as a result of direct or indirect violence; the extent of the wound; and the extent of the injury to blood vessels, nerves, muscles and tendons.

In compound fractures the primary consideration is the prevention of infection. Accordingly, they may be classified

into two main groups. First, those that are seen early with relatively little soft tissue damage. Second, those with extensive macerations of the soft tissues and considerable foreign material in the wound, observed twelve hours or more after the injury. In the first group, after mechanical cleansing and débridement, the wound is closed with the reasonable expectation of not having an infection; subsequently, the treatment is that of a closed fracture, that is, manipulation, reduction and immobilization in a cast.

For extensively macerated wounds wherein the ankle joint and bones are exposed and considerable foreign material is present, the wound is irrigated and cleansed with copious quantities of normal saline solution. During this procedure all portions of the wound are gently massaged with the gloved hand in order to remove as much extraneous matter as possible. This procedure is of far more value in the prevention of infection than the douching of the wound with antiseptics. Strong, caustic solutions cannot be expected to sterilize the wound completely. Instead, the probability of infection is enhanced from coagulation of the proteins and necrosis of the superficial cells.

After a thorough débridement and removal of all devitalized tissue, the question immediately arises as to whether the wound shall or shall not be closed. There are no rules that are applicable to every case but in general the following suggestions are offered: If there has been an extensive amount of maceration of the soft tissues, considerable foreign material in the wound, and the fracture is of more than twelve hours' duration, thereby precluding the possibility of treating it as a closed fracture, drainage is always instituted. Reduction should be carried out at the time of the acute injury, or at least after a reasonable period of time following the determination that an infection will not occur; otherwise, there is little possibility of restoring the fragments to their proper anatomic position. The foot and leg may be temporarily immobilized in an adequate type of observation splint with skeletal traction, particularly if the Carrel-Dakin technique is instituted. Otherwise, the fracture is reduced, a cast applied, and windows are cut in such a manner that the wound can be observed at frequent intervals; it is of utmost importance that gas or pyogenic infections be discovered in their incipiency.

In the last two years sulfanilamide has been administered routinely in all compound fracture cases as a prophylactic for the prevention of both gas and pyogenic infections; the results of this treatment have been very favorable. While both types of infection have occurred, the infections have been less severe and virulent and have cleared up in a shorter period of time. Both from a medicolegal and therapeutic standpoint, it is wise to administer anti-tetanus serum, though there is considerable argument to the contrary. The use of the combined anti-gas and anti-tetanus sera has not been impressive.

FRACTURES OF THE ASTRAGALUS

There is little in the literature to guide one as to the proper treatment of fractures of the astragalus, and this abounds with a diversity of opinion. The low incidence, the high percentage of poor results, and the unusual anatomy and physiology of fractures of the astragalus present an interesting though confusing problem. The blood supply is notoriously scant and, therefore, the bone is subject to aseptic necrosis. Further, its large articular surfaces and numerous weight bearing facets afford plentiful areas for injury with a resultant traumatic arthritis. In considering these complicating factors it is easy to account for the varied ideas as to proper treatment.

The blood supply of this bone has not been completely worked out. The clinical evidence would lead one to believe that

the majority of the circulation enters the astragalus through the neck. This does not mean that fractures through the neck proximal to the principal source of blood supply will always result in a necrosis of the body but this factor must always be considered.

Fractures of the astragalus are classified according to anatomic location as those of the posterior process, the neck and the body. Fractures of the posterior process rarely cause any subsequent disability since the displacement is usually of minor degree and mere immobilization in a boot cast in the neutral position for six weeks will suffice for union in a satisfactory position. Small chip fractures in this region may be confused with an os trigonum.

Fractures through the neck without displacement are treated by immobilization alone. With displacement of the fracture, particularly where the head is rotated and displaced and the body rotated so that the fracture surface is in contact with the os calcis, more drastic measures are indicated. If the major portion of the circulation to the body is from the neck, certainly anatomic reposition and maintenance of this position is imperative. If conservative measures are inadequate, open reduction and internal fixation should be resorted to immediately, without waiting until malunion is established or the body of the astragalus has become an aseptic sequestrum. After open reduction, reposition of the fragments is anatomic; capillaries reform rapidly across the fracture site, reëstablishing the blood supply from the neck to the body; internal fixation prevents any motion between the fragments which would disrupt this revascularization process. Internal fixation is obtained by a homogenous bone peg passed through a hole on the medial surface of the head, posteriorly and laterally into the neck and body.

The proper treatment of fractures of the body of the astragalus is a matter of varied opinion, the only point of agreement being those fractures wherein there is little displacement; these are adequately treated by immobilization alone. In fractures of the body of the astragalus Miller and Baker believe that the fracture-dislocation can rarely be satisfactorily reduced by closed methods; that open reduction and reposition of the fragments permit an accurate reduction with less manipulation and manhandling of the fragments than conservative methods. Further, if entirely satisfactory reduction cannot be obtained, they believe that subastragalar arthrodesis should be considered as an early measure; first, to prevent subsequent traumatic arthritis, also as a possible source of blood supply to an impending aseptic necrosis of the body of the astragalus. They condemn astragalectomy as improper treatment with the exception of those cases in which the astragalus is an infected sequestrum.

According to Key and Conwell, when reduction cannot be effected by manual force, skeletal traction should be instituted through the os calcis and continued over a period of three or four weeks, then followed by a boot cast.

Other authors believe that in severely comminuted fractures of the body of the astragalus, excision or astragalectomy is the procedure of choice. Of ten patients upon whom Gray and Faulkner performed astragalectomy for this fracture, five obtained a stable and painless foot, in two the result was fairly successful and in three the outcome was disappointing.

While astragalectomy in adults with normal musculature has been successful in a few cases, the majority of the results have been disappointing; either the weight bearing position has been poor or the articulation has been painful. If possible, some other procedure is preferable, either surgical measures to restore proper position or conservative treatment. If incongruity of articular surfaces should result in pain after a year's trial of weight bearing with support, one always has recourse to fusion of the subastragalar joint or ankle joint

or both. A fused ankle in a satisfactory position is a relatively satisfactory, painless and stable weight bearing member. On the contrary, astragalectomy is performed without hesitation when the bone is an obvious infected sequestrum that blocks drainage and must be eventually extruded from the wound before healing can occur. These cases have turned out satisfactorily in that as a rule there is little or no motion between the ankle mortice and the articulating surface of the os calcis, fibrosis being so extreme as to end practically in a fusion or ankylosis. If the foot can be maintained in a satisfactory position during this period of fibrosis, a satisfactory weight bearing foot may eventuate. On the other hand because of continued infection, poor position as to backward displacement, or deformity, amputation may be preferable.

DISLOCATIONS OF THE ASTRAGALUS

Dislocations of the astragalus without fracture are relatively rare lesions. The mechanism of the dislocation is forceful plantar flexion of the ankle as would result from catching the heel on a step or curb, the astragalus being squeezed forward from the ankle mortice onto the dorsum of the foot. The circumstances of the individual case must dictate the treatment as to closed or open reduction.

SUMMARY

Fractures and fracture-dislocations of the ankle must be considered as emergencies and as such receive emergency treatment. While a certain amount of deviation from normal anatomy may be acceptable, in general, the end results are commensurate with the accuracy of the reduction. Recurrence of displacement after an accurate initial reduction is not uncommon, thus necessitating frequent observations to preclude malunion. Open reductions are appropriate when conservative measures are inadequate. The primary object of the treatment of fractures is the reposition of the fragments; if necessary, the beneficial effects of weight bearing are always disregarded in favor of maintenance of position.

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ACUTE INFECTIONS OF THE EXTREMITIES*

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IN any consideration of infections in the extremities one must consider certain differences between the upper and the lower. The hand is more subject to injury and may develop blisters or cracks in the thickened palm of those doing manual labor, whereas the foot is more likely to develop corns, calluses, perforating ulcers and ingrowing nails. The foot in relation to the heart is in a more distal and dependent position and is more likely to have an inadequate arterial inflow or an inadequate venous or lymphatic return flow. In the presence of infection both the upper and lower extremity should be elevated but this is more imperative for the foot. Rest and moderate elevation of the hand can be obtained by the use of a sling while in the case of the foot it is necessary to put the patient to bed to gain these ends. The hand is the more highly developed and complicated structure so that stiffness and scarring may result in great disability, while the foot and leg is a weight-bearing member, where tender scars and thin skin on the sole may be incompatible with satisfactory function.

In a discussion of acute infections of the extremities, as in any disease, the most important consideration is prophylaxis, but unfortunately the doctor is consulted only after the infection is well under way so his usual duty is treatment. He may, however, treat the larger injuries which form portals of entry for infection and by careful cleansing and débridement place the wound in such condition that infection will not develop. He also may have many opportunities to give timely warnings or advice as to how to avoid infections and the public will, in time, profit through a general dissemination of knowledge.

Injuries, particularly puncture wounds, should be guarded against. This is especially important for those handling small children whose soiled diapers are held on with safety pins that must be inserted and removed many time a day. Possibly some day these dangerous insignia of early life will pass into the discard in the interest of greater safety for mothers and nurses. Any wound should receive first aid at the earliest moment, but if there has been delay in treatment and it seems that infection is likely to occur, the wound should be left open and dressed to facilitate drainage by preventing crusting and drying. Frequently this will stop the spread of the infection and promote early healing.

Small hangnails should not be pulled, since the cleavage plane extends deeper as it progresses toward the base of the nail. Where there is no tenderness and no break in the skin these should be trimmed short and sealed over with collodion. When the hangnail has extended deep enough to cause bleeding or serous drainage it should be trimmed short, but instead of being sealed over it should be dressed to facilitate drainage. Many an early infection in a small wound can be checked within one night if drying is prevented by a wet dressing or by a liberal application of an ointment beneath the dressing.

Sterile blisters or those caused by a fungus infection (epidermophytosis) should be treated so as to avoid contamination or secondary infection and when drainage does occur it should be free in order to

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avoid absorption and extension of the potential infection.

Every patient with any disturbance of sensation (nerve injuries, syringomyelia, paralysis, etc.) should be warned about the dangers of burns and injuries. Individuals with poor circulation, particularly when it is associated with some debilitating disease such as diabetes, or nephritis, should be cautioned as to the dangers of cutting corns, calluses, and ingrowing toenails. They should have their feet cared for by a physician who understands the dangers of the most trivial wound and can exercise aseptic precautions even when fairly confident that his treatment will not open a portal of entry for infection. With the slightest evidence of infection in such a patient treatment should consist of rest, both local and general, the best position to insure the maximum blood supply to the part, and local applications to facilitate drainage.

Fungus infections should be treated for the avoidance of blisters or cracks. The dead skin can be peeled off with salicylic acid and the fungus growth inhibited by applications of dilute solutions of iodine. When cracks or blisters occur every precaution should be taken to avoid secondary infection. When the fungus infection is acute the part should be kept dry and secondary infection should be guarded against. If secondary infection takes place free drainage should be obtained by the use of wet dressings or non-drying ointments to prevent crust formation.

After any infection has gotten well under way the treatment may be divided into four main divisions:

I. Improve the resistance of the patient.
II. Provide free drainage at the proper time.
III. Prevent deformity.
IV. Restore function

I. In seeking to improve the resistance of the patient we must consider:

A. The general condition of the patient.

B. Local conditions in and about the area of infection.

A. 1. The patient should be placed at rest both physically and mentally.
2. He should take an easily digestible diet, rich in vitamins, giving adequate salts and nourishment, and with a minimum of waste products to be excreted.
3. He should receive 3,000 to 5,000 c.c. of fluids every twenty-four hours, the exact amount depending on the condition of the patient, and the general temperature and humidity levels
4. Elimination should be adequate.
5. The hemoglobin should be maintained at as near a normal concentration as possible, by the use of diet, liver extract, and transfusions as indicated.
6. The immunity should be increased whenever possible. This may be done by the use of specific immune serum when it is available. Multiple small transfusions may confer some immunity at times, in addition to maintaining the hemoglobin level
7. Chemotherapy has in recent years assumed a place of great importance in infections. The most important drugs are sulfanilamide and the allied products for streptococcal, gonococcal, gas bacillus, and other infections; the arsenicals for the fusospirochetal infections that may follow human bites; and iodine and iodides for fungus infections. If there are no contraindications these drugs should be used whenever the organism is of a type which may be affected.

B. In order to improve the resistance at the site of the infection any or all of the following local measures may be indicated.

1. Rest. The patient should be kept at rest so that any massaging action on the infected area may

be avoided. Immobilization may be indicated, particularly if the infection is near a joint.

2. In addition to the patients having a normal quantity of blood, it is necessary to insure its maximum availability at the point of conflict between the organisms and the body. The body responds to the infection with a dilatation of the capillaries and smaller vessels, with a slowing of the blood flow, and the passage of leucocytes into the tissues. This hyperemia may be stimulated further by the application of heat, preferably as wet dressings, since these may be applied without the part being markedly dependent, as when it is soaked in a tub. The moisture also prevents crusting and facilitates drainage where there is a break in the skin.

   X-ray is used at times in the treament of certain localized infections. Aside from any effect it may have on the organism its principal action is in producing a hyperemia. When a fungus growth is harbored about the hairs or nails *x*-ray may be used for temporary removal of these structures. If properly given, the risk of a burn should be slight. A greater danger would be undue delay in providing adequate drainage following the local formation of pus.

   Passive hyperemia, as advocated by Bier, may be beneficial, but care should be taken to see that the congestion is not too great since then it may do more harm than good. The dependent position causes a passive congestion which may result in increased edema and swelling and be detrimental to the defense mechanism. Unless used in moderation and with intelligence, passive hyperemia can do more harm than good.

3. Elevation. The part should be elevated in order to limit swelling and edema by favoring venous and lymphatic return flow. This also improves the circulation since too great swelling impairs not only the venous return but also the arterial inflow.

II. Provide free drainage. This may be used (A) in the very early stage of infection without surgical incision to prevent extension and abscess formation; or (B) in the later stages, after pus has formed, by a surgical incision to relieve tension, limit extension, and facilitate healing.

A. The wound of short duration with tenderness and evidence of early superficial infection, whether it be a large laceration or a hangnail, should be dressed to obtain the maximum drainage. Hot wet compresses of physiologic salt solution, boric acid, or magnesium sulfate are best, but if it is inconvenient to apply these a dressing with a liberal application of vaseline or an ointment with a vaseline base will prevent the formation of a crust. This encourages drainage and may prevent direct extension or a spread by way of the lymphatics or tissue planes and may obviate gross suppuration and abscess formation.

B. After a pocket of pus has formed it should be drained through an adequate opening or incision at the earliest moment, to stop the destructive process, limit infiltration and fibrosis, and prevent spread from one space to another. This is particularly necessary in such a complicated and delicately adjusted structure as the hand. The incision should be so placed as to avoid damage to important structures or opening of new cleavage planes to the infection, and should be large enough to insure free drainage with the minimal amount and the shortest period of insertion of drains since the latter may stimulate

fibrosis and the formation of crippling adhesions. After incision and drainage the part should be treated with hot wet dressings, but in the healing stage a dressing with an ointment to prevent drying may be used.

Caution: The principal pitfall in the use of compresses is the maceration of the skin with secondary transplanted infections such as boils or carbuncles beginning in the hair follicles. To prevent or minimize this danger the following precautions should be taken:

Wash the skin thoroughly with 70 per cent alcohol between compresses.

Periodically leave the skin exposed to the air for drying.

Mildly antiseptic compresses such as boric acid may be used. *Irritating chemicals, however, must be avoided.*

The skin may be painted with gentian violet to inhibit the growth of the Gram-positive cocci. This is particularly valuable in the axilla where the skin containing many hairs and glands tends to remain moist, making it difficult to avoid reinfection.

C. Necrotic tissue should be removed with the minimal trauma. The sooner the dead tissue (fascia, tendon, bone, etc.) is removed the quicker healing will take place and the less infiltration and fibrosis there will be. However, there are many occasions when a wait for a natural line of dermacation is less damaging than the unavoidable trauma to viable tissue in the early removal of the dead part, such as a piece of bone.

III. *Prevention of deformity* is imperative if we are to avoid needless crippling disabilities. These are usually easier to avoid than to correct. Mobility of joints should be maintained if possible, and where there is danger of loss of mobility the part should be kept in the position of greatest functional use. The knee should be slightly flexed, foot drop should be prevented, the elbow should be flexed so the hand can be brought to the face, head, chest, etc., the forearm should be between pronation and supination but with supination preferable to pronation, the wrist should be moderately extended in the position assumed with the maximum grip, the fingers should be in moderate flexion, and the thumb should be out opposite the palm and fingers in a position where it can be brought into apposition to the partly flexed fingers or be used for gripping an object in the palm. All too frequently we see patients with a long-standing infection of the hand who have had the part extended in pronation, with the wrist slightly flexed, the fingers fully extended and the thumb and thenar eminence in the same plane with the palm. Fixation in this functionally useless position can be avoided by the use of a splint for extension of the wrist, allowing flexion of the fingers. The palm support must not hold the thenar eminence and thumb in the plane of the palm but must allow them to assume their normal position of rest. Passive, and later active motion, should be used to maintain mobility in the joints as soon as the infection will permit.

IV. *Rehabilitation.* Much can be done to simplify rehabilitation by early diagnosis and treatment and by taking precautions to prevent deformities and fixation of joints.

When the infection subsides rapidly there is little need for treatment other than free drainage during the stage of infection. Following healing the part soon returns to a normal range of mobility as a result of routine use. When such rapid resolution does not take place and cannot be hastened due to the underlying pathologic condition, mobility of the joints should be maintained by passive and, at times, active motion. In some cases such motion causes a distinct improvement as a result of better drainage and a diminution in the swelling.

After healing is complete any stiffness or deformity should be treated by baking, massage, paraffin baths, and other physiotherapeutic measures. Contractures may demand traction or may have to be released

by surgical procedures, and missing tissue may be replaced by a suitable type of graft.

When a part is damaged beyond hope of repair and is a handicap to the best function of the remainder of the extremity, it should be removed. In the case of the foot this might require amputation if the body as a whole could be made to function better with a good artificial foot. In the case of the hand a stiff finger may be removed if sufficient motion cannot be obtained to prevent it from being a handicap for a given individual in a given occupation. Under no circumstances, however, should the thumb be removed if any part of it can be saved.

In the more serious and rarer types of infection (e. g., tendon sheath, etc.), it is essential for the welfare of the patient that he be placed under the care of a surgeon who has had experience in handling such conditions and can give him the greatest chance of obtaining complete recovery. Delay even of a day or two may mean permanent crippling which otherwise might have been avoided.

SPECIAL TYPES OF INFECTIONS*

Acute lymphangitis with red tender streaks extending from the focus of infection up the extremity along the course of lymphatic drainage and associated with regional lymphadenitis and occasionally with chills and high fever, is well known and its gravity is fully appreciated by the profession and the public. Most frequently it is caused by the hemolytic streptococcus, but may be caused by other organisms.

The diagnosis of such a condition is evident, but we should keep in mind that there can be a lymphangitis of the deep lymphatics when there is no redness, but a diffuse swelling with tenderness along the course of the deep lymphatics and with involvement of the associated lymph nodes.

Treatment demands rest, both local and general, elevation, and hot wet dressings to the wound of inoculation and the entire involved extremity. If there is localized pus formation free drainage should be instituted. The lymphadenitis may be treated with cold applications so long as there seems to be any chance of preventing suppuration in the glands. If the lymphangitis seems to be severe or is not definitely subsiding within twelve hours after treatment is instituted the patient should receive sulfanilamide, sulfapyridine or such allied product as seems indicated. With early treatment the prognosis is good. The acute lymphatic involvement subsides within twelve to forty-eight hours. In an occasional case there may be suppuration in the adjacent lymph nodes which may have to be drained. In some neglected cases, and occasionally in adequately treated cases where the resistance is poor or the infection particularly virulent, the organisms may reach the blood stream, causing a septicemia. The infection is then generalized and must be treated as such. In occasional severe infections which do not become generalized there may be any degree of necrosis of tissue with abscess formation. Such abscesses should be drained and treated with hot wet dressings and all measures for combating the infection.

Erysipelas involving the extremity, similar to this disease elsewhere, is caused by a streptococcal infection in the skin lymphatics and should be treated by sulfanilamide or some related drug, preferably associated with the use of streptococcus antitoxin or serum. The general principles of treatment of infections should also be applied. When there is an associated lymphangitis and cellulitis with abscess formation these should be treated with hot wet dressings and the latter should have adequate drainage.

Boils and carbuncles are particularly likely to occur on the hands in the hair-

* Detailed descriptions of the anatomy of the hand and the special types of infections cannot be covered in an article of this type. Illustrations also would be too numerous to publish. For illustrations, more detailed descriptions, and consideration of the more serious and special types of infections the reader is referred to Kanavel's pioneer work on the hand, to Lewis' "Practice of Surgery," Nelson's "Loose-Leaf Surgery," other textbooks of surgery, and the numerous articles in the literature.

bearing areas and occasionally may occur elsewhere on the extremities. As soon as pus forms they should be drained by a crucial incision, taking care in the case of carbuncles to undercut the flaps so as to open all the channels of pus, but not to incise so deep or so far laterally as to cut through the defense barrier, either fascial plane or zone of leucocytic infiltration. Every precaution must be taken to prevent transplantation of the organisms to other parts of the skin. These precautions are particularly necessary when wet dressings are being used.

Paronychia, a pyogenic infection in the tissues lateral to the finger nail, and eponychia, an infection of the tissue superficial to the nail root, occur most frequently secondary to a hangnail but may follow any puncture wound in this region. In early cases the infection may be limited to one side of the nail and not involve the eponychium, but in neglected cases the infection extends around the base of the nail, the popularly named "run around," and extends beneath the root of the nail which becomes detached and acts as a foreign body. (Fig. 1.) This foreign body together with inadequate drainage causes the condition to become chronic with a resultant growth of redundant granulation tissue which still further obstructs drainage.

Treatment. In the very earliest stages when a hangnail or puncture wound becomes "sore," wet dressings or maceration of the epidermis and dried secretion with an ointment may give free drainage and the condition may subside. In the somewhat more advanced stage the swollen soft tissues may be pushed gently away from the side or base of the nail with evacuation of a drop of pus. Following this the infection may subside with wet or ointment dressing. If there is not rapid improvement, however, free drainage should be secured by an adequate incision, performed preferably under nitrous oxide or cyclopropane anesthesia unless the pus is so superficial that it can be obtained without undue pain. When the entire base of the nail is involved the nail root and all undermined parts of the nail must be removed. (Fig. 1.) An incision lateral to the nail root may or may not be necessary to secure free drainage. In some advanced cases where the nail root is completely detached it is possible to remove it without any anesthesia. The distal part of the nail should be left in place if it is not detached. Under no circumstances may an incision be made into the bed beneath the nail root since this will result in a split in the new nail. (Fig. 2.) The incision must not endanger the distal interphalangeal joint as a pyarthrosis and osteomyelitis would likely follow opening of the joint space.

Ingrowing Toe-Nail. In the foot an ingrowing toe nail predisposes to an infection in the tissues lateral to and beneath the edge of the nail. Here also the edge of the nail acts as a foreign body and must be removed. In the early stages infection may be avoided or allowed to heal if the edge of the nail is elevated by packing cotton beneath the edge. In certain patients the condition may be relieved permanently by this method if the nail is allowed to grow longer at all times. In the more severe cases it may be necessary to remove part of the nail and the matrix from which it grows. An incision demarcating the part to be removed is made through the nail, through the soft part over the root, through the root and the nail bed. The lateral part of the nail is removed along with all the matrix from which the removed part grows. The wound is thoroughly washed out. If infection is present the wound is packed open with vaselinized gauze. Redundant granulation tissue should be removed. In the acute stage of infection drainage should be established, but it is unwise to remove the offending part of the nail if adequate drainage can be obtained otherwise. It is imperative that the incision not extend into the distal interphalangeal joint, a complication which I have seen. If free of infection the flap superficial to the nail root may be sutured back in place with one suture. When this is done close observa-

tion for evidence of infection is imperative. If this develops the wound should be opened and treated by wet dressings and other measures to control infections.

dorsum of the finger but is particularly susceptible to inoculation through puncture wounds. It is surrounded by a dense fascia which is attached to the bone by

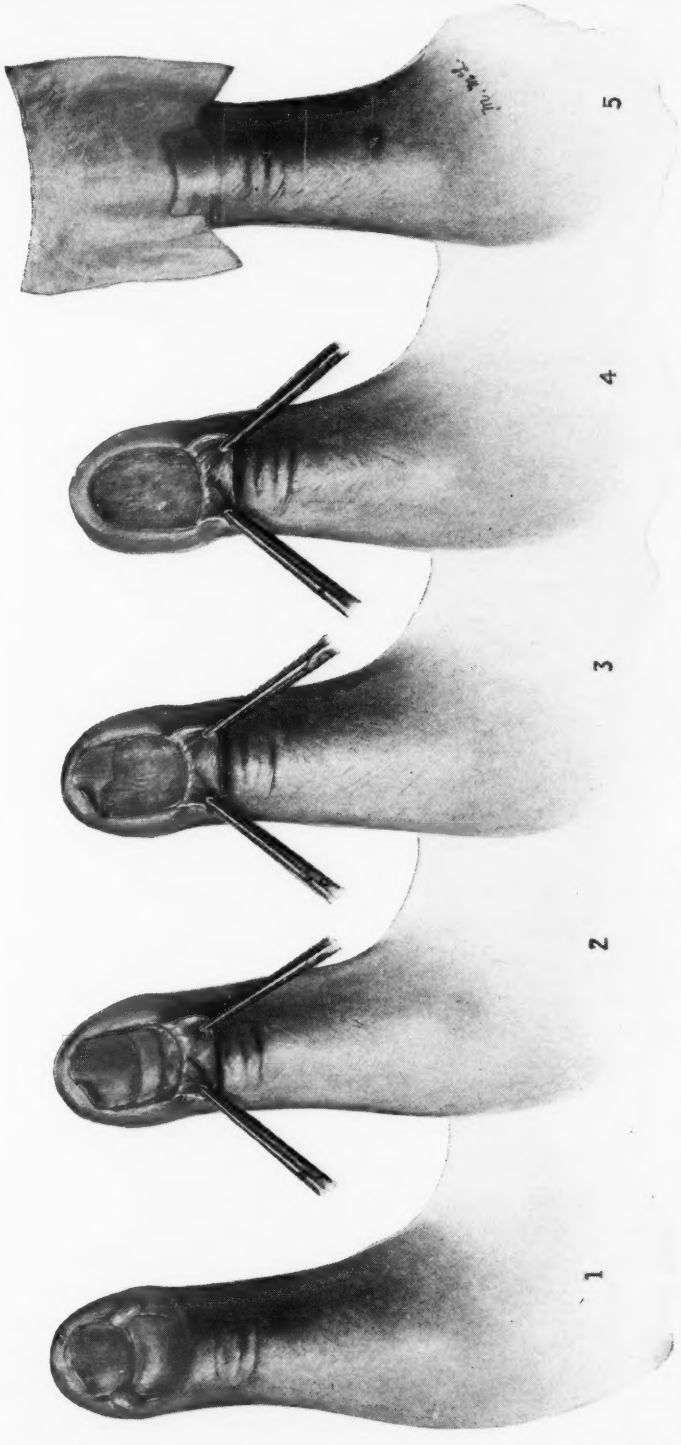

Fig. 1. Operation for paronychia with subungual abscess. 1, incisions to either side of nail avoiding matrix. 2, nail root exposed. Nail root may be removed without the lateral incision if free drainage can be obtained. 3, undermined part of nail cut away. 4, nail completely removed since the small fragment was not stable. 5, gutta percha or rubber placed beneath soft part flap to serve as drain.

The anterior closed space on the palmar side of the distal phalanx of the finger is well separated from the infections on the

fibrous strands. These divide the space up into pockets, may direct the pus toward the bone, limit the amount of swelling, thereby

causing an increase in tension which may be great enough to interfere with the blood supply in the vessels which pass through this space. The bone may be infected by direct extension or the osteomyelitis may be secondary to necrosis resulting from cutting off of the blood supply. A diagnosis as to the presence of pus must be based on the throbbing pain, tension, and exquisite tenderness on point pressure, since fluctuation cannot be elicited due to the tension and the small volume of pus present.

Treatment. Early incision with the relief of tension is indicated if extensive destruction of tissue and an osteomyelitis of the distal phalanx is to be avoided. Incision for drainage should be made on the side of the finger volar to the bone with care to avoid the nerves and blood vessels. The incision should extend through the fibrous trabeculae in the infected area. Only rarely may it be desirable to make bilateral incisions with through and through drainage. The horseshoe incision extending around the end of the finger with complete undercutting of the palmar pad leaving it as a flap is seldom justified.

The one exception to the use of the lateral incision is the presence of a superficial or subepidermal abscess on the volar aspect of the distal phalanx and not involving the anterior closed space (therefore not an anterior closed space abscess but may be confused with it). In treating such an infection, however, the possibility of a collar button type of abscess with part of the abscess beneath the fascia must be kept in mind.

Infections beneath a callus in the palm occur fairly frequently and should be treated by removal of the callus to provide free drainage. Such an infection may give marked edema of the dorsum of the hand since the lymphatic drainage is to the dorsum. The diagnosis, however, should not be confusing if one searches for induration and the point of maximum tenderness, and ignores the soft pitting edema. A careful examination must be made to rule out or confirm the presence of a collar button type of abscess with an extension beneath the palmar fascia. Because of the difficulty in cutting through the callus and the extreme tenderness resulting from pus under pressure, general anesthesia may be necessary. Unconsciousness of the patient, however, should not give one freedom to use any more force or pressure than is absolutely necessary to remove the callus with the sharpest scalpel.

Infection of the Foot in Diabetics. In no field of medicine is the close coöperation of the surgeon and internist more imperative. Perforating ulcers on the feet in patients suffering from diabetes, with an associated trophic disturbance secondary to a neuritis, beginning beneath a callus, are usually chronic but may be the starting point of an acute infection. The patient with diabetes, particularly if in the older age group, not infrequently has an associated arteriosclerosis. The combination of poor blood supply and decreased resistance to infection makes any acute infection extremely serious since it is a threat both to the limb and to life.

Prophylaxis can be applied in such patients by keeping the diabetes under control and by seeing that they have adequate care of the feet with avoidance of or treatment for calluses, corns, ingrowing toe-nails, etc., avoiding if possible the formation of any portal of entry for organisms. Every precaution should be taken to avoid injury and infection. With the most trivial wound the part should be elevated and put at rest. Early infections should be vigorously treated and in every case of injury or infection the diabetes should be brought or kept under control if possible. With infection once well established moist gangrene is likely to follow if there is an impaired blood supply. Drainage should be established by warm wet compresses alone in the early stages and by incision and wet compresses if there is formation and localization of pus. The local circulation should be stimulated, but not by the use of pressure and suction methods.

So long as there is promise of bringing the infection under control every effort should be made to save the part. In many

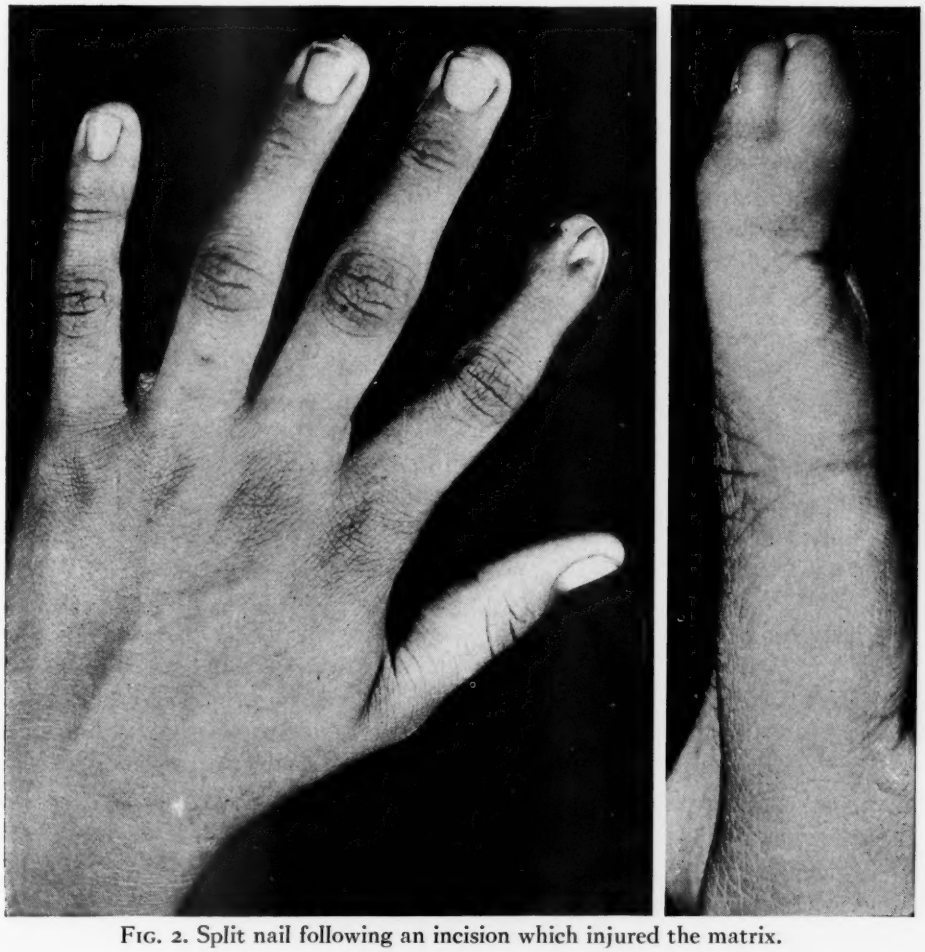

Fig. 2. Split nail following an incision which injured the matrix.

cases there may be no loss of tissue or only the loss of one or two toes. When the loss of the foot seems inevitable it should be removed at such level as seems indicated by the blood supply. In any case there is danger of severe infection, most commonly with a streptococcus, gas bacillus, staphylococcus, occasionally tetanus bacillus or a combination of organisms, in the amputation stump, particularly if the amputation is below the knee. The organisms are probably in the tissues at the time of operation, having reached the operative site by way of the lymphatics, cleavage planes, or muscles. My personal choice of method of amputation is to try to avoid infection by giving the least favorable ground in which organisms can grow. Of course every detail of aseptic technique as we now know it is also employed. No tourniquet is used, and as few ligatures of the finest silk possible are used to ligate only the isolated blood vessels. Complete hemostasis is secured. No tissue is crushed, only sharp dissection is used, tension is avoided in closure, no drains are inserted, very few buried sutures are used, and these contain in the loop the minimal amount of tissue. Both the buried and skin sutures of silk are tied so loosely that slight tension will separate the approximated tissues, indicating that subsequent oedema will not produce strangulation. The dressings are applied snugly but should not cause any undue compression. If it is felt that such a closure is not feasible the wound is left open following amputation, is closed loosely

with through and through sutures of silver wire which allow drainage, or the amputation is performed at a higher level.

No compromise measures such as use of catgut, and insertion of drains are used since they will make the risk of localization of the infection and suppuration far greater. We try either to avoid any localization of bacteria or leave the wound open for the freest drainage. If infection does occur, in a patient whose general condition is good and there is an adequate blood supply, the wound should be opened for free drainage, hot wet dressings should be applied, the part elevated, and all measures for combating infection should be used. Secondary closure can be carried out later after the infection has subsided. In the presence of a somewhat diminished blood supply, at times healing can be secured by the use of skin grafts. When the area is covered with epithelium it can be treated as a clean wound and a plastic repair carried out to secure a good stump for an artificial limb.

If the patient's condition is serious, the circulation poor, and severe infection occurs in an amputation below the knee, the best chance of saving the patient's life may lie in re-amputation just above the knee, avoiding damage to large muscles and leaving the wound open for drainage and secondary closure. In any amputation in the presence of a moist gangrene with severe infection, tetanus and gas bacillus antitoxin and sulfanilamide should be used as prophylaxis against infection localizing in the operative wound.

Gas Gangrene. Acute Infectious Gangrene. Gangrene may occur when the blood supply is inadequate from any cause. If infection gains entrance to the deeper tissues moist gangrene may be precipitated in an extremity which otherwise might survive. Treatment should be similar to that given for gangrene and infection associated with diabetes, except that the patient's general and local resistance may be better, there may be a better chance of saving the extremity, and we do not have the complicating diabetes to be kept under control.

Severe infections may occur anywhere in the extremities following severe or even trivial puncture wounds. These are likely to be most severe following compound fractures, or crushing injuries with extensive devitalization of tissues. I have seen such a result following a bullet wound in which a large amount of cloth or wadding was carried into the wound and not removed for several days. The type and severity of the infection depends both on the number and pathogenicity of the organisms and on the local and general resistance of the patient. All these conditions can be altered greatly by adequate first aid and many of the infections can thus be avoided. The most dreaded infections are those caused by the gas-producing organisms, the hemolytic streptococcus and hemolytic staphylococcus. All these infections may be influenced greatly by the recent addition of sulfanilamide and related drugs to our treatment by chemotherapy. In all severe injuries adequate prophylactic doses of tetanus and gas bacillus antitoxin should be given at the time of injury and should be used in larger therapeutic doses in case infection develops.

An infection with the gas-producing organisms may lead to gas gangrene, particularly when the wound is soiled, heavily contaminated, and the tissues, particularly the muscles, are traumatized.

Symptoms of gas gangrene are abrupt in onset, with a high temperature and rapid pulse, associated with restlessness, apprehension, general prostration, and an increase in the tenderness, swelling, and evidence of inflammation in the wound. Gas in the tissues, if subcutaneous emphysema from other causes can be ruled out, is diagnostic and may be detected by palpation, auscultation or roentgenograms. Drainage from the wound is likely to be serosanguinous, have a characteristic odor, and smears will likely show the large Gram-positive Welch bacillus. There are, however, a number of other gas forming organisms

which may be present alone but the wound flora will likely be mixed. Unless the specific organism causing the infection is identified a polyvalent serum should be used.

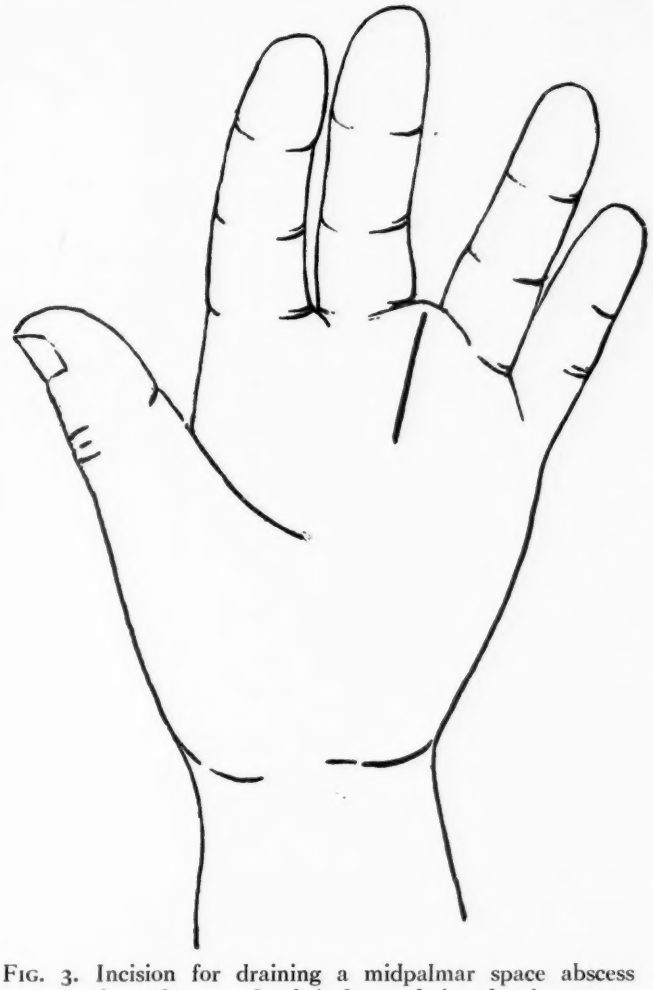

Fig. 3. Incision for draining a midpalmar space abscess presenting along a lumbrical canal in the interspace between the third and fourth fingers. The incision is placed distal to the vascular arches and between the vessels and nerves to the fingers. The palmar space is opened by inserting a clamp along the lumbrical canal, spreading this to give free drainage.

The infection spreads principally along individual muscles though many of these may be involved, particularly if they have been damaged.

Prophylactic treatment consists in adequate care of the original wound along with the use of serum. Depending on the likelihood of infection, the patient may be given sulfanilamide as a prophylactic measure. After the infection has started, serum and sulfanilamide should be given in large quantities, the wound should be opened widely for free drainage, and infected and necrotic muscles should be removed. Even before the advent of sulfanilamide and associated drugs many of these patients were cured without loss of the extremity if the infection was not associated with a compound fracture. The percentage of patients cured without amputation should increase now that these new drugs are available. In the severe infections associated with compound fractures, in extensive infection associated with widespread damage to the tissue, and in the case of infections

in patients who put up little resistance, amputation may be indicated in order to avoid too great a risk of loss of life. The amputation wound should pass through as few muscles as possible and should be left open for drainage. Treatment with tetanus and gas bacillus serum and sulfanilamide should be continued until the infection has subsided and all danger of spread has ended.

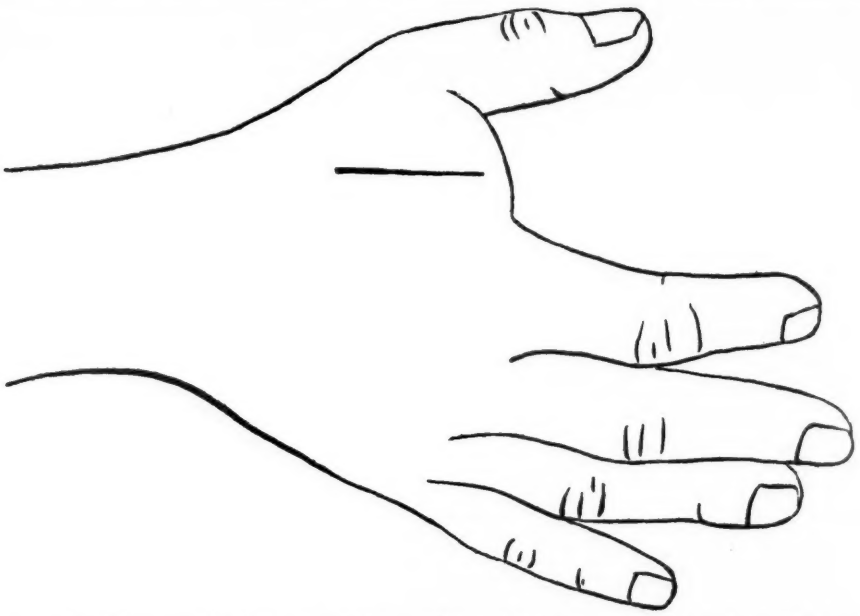

FIG. 4. Incision on the dorsum of the swollen web between the thumb and index finger for drainage of a thenar space abscess. The abscess is opened by passing a hemostatic forceps along the palmar surface of the adductor pollicis muscle to enter the abscess cavity. The drainage tract is enlarged by spreading the clamp.

Streptococcal infections, when once established, should be treated by the use of sulfanilamide and anti-streptococcus serum, by adequate drainage, as soon as there is pus formation, and by all other methods of combating infection.

Rarely we may have gangrene of the subcutaneous tissue and skin caused by hemolytic streptococci as reported by Meleney and others. The wound of entry is usually trivial but may be severe. There is a rapid spread with extensive necrosis of the subcutaneous fat and a somewhat less extensive necrosis of the skin resulting from the thrombosis of the blood vessels supplying the area. There may be an associated septicemia and metastatic abscesses, in which cases the prognosis is grave.

Treatment of this subcutaneous gangrene consists in early operation as contrasted to other streptococcal infections when we wait for formation of pus. The incisions should extend to the edge of the subcutaneous necrosis. Hot wet dressings, sulfanilamide, and all methods of combating the infection and supporting the patient should be continued.

Hemolytic staphylococcic infections may be quite serious and should be treated by all the methods of combating infection and increasing the resistance of the patient that are at our disposal. In addition, staphylococcus antitoxin and sulfapyridine are very beneficial. When the infection is severe they should be used in large quantities but always within the patient's tolerance. They may be used in combination or separately.

Web space infections are self-evident from the tenderness and ballooning of the web between the fingers or toes. The only question of diagnostic importance is the extent of the infection and the location of the pus. Not infrequently an infection of the palmar or thenar space may extend along a lumbrical muscle to point in the web, or an infection in the web may extend along the

lumbrical muscle to involve the deeper fascial planes in the palm. Treatment consists in operative drainage through a lumbrical muscle should be enlarged by dilating it with a hemostatic forceps.

Occasionally in soft corns between the

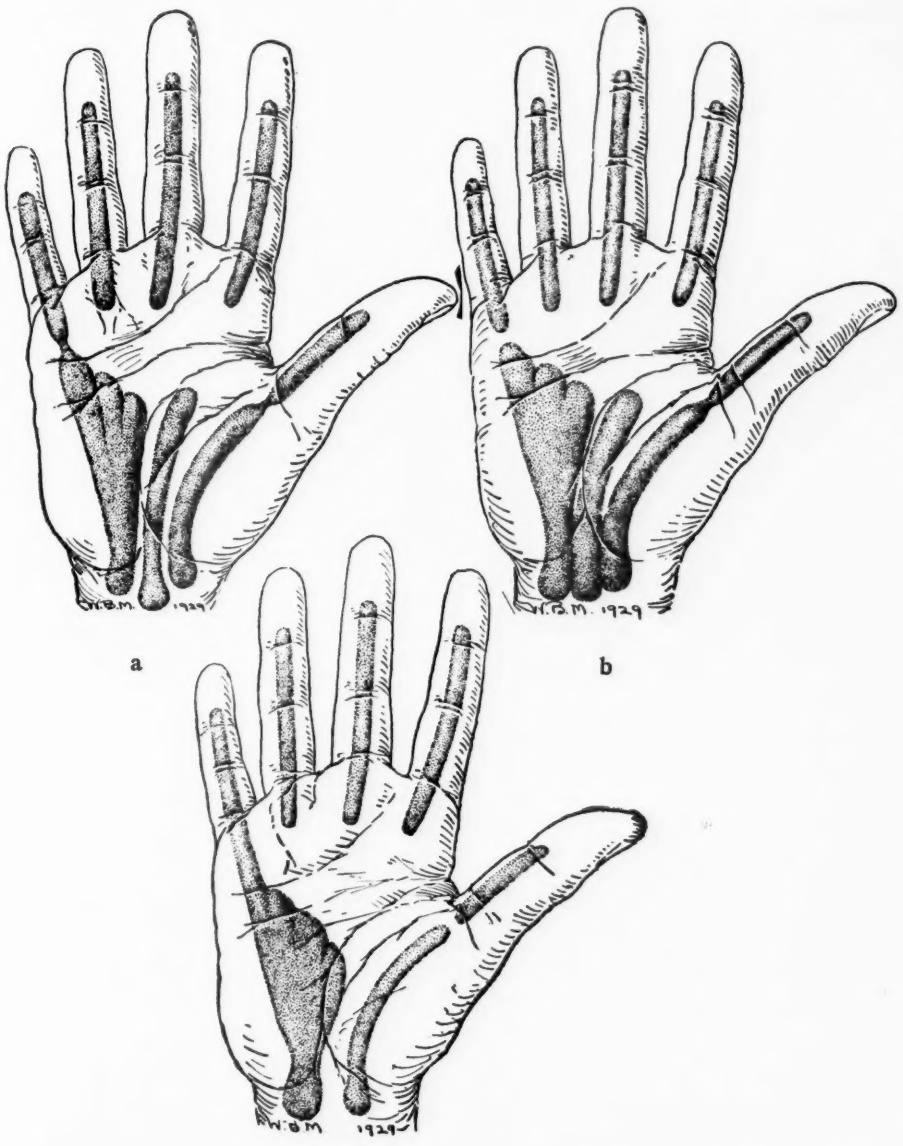

Fig. 5. Synovial sheaths of the flexor tendon. Anatomic variations are shown in *a*, *b*, and *c*. The usual arrangement is for the ulnar and radial bursa to be continuous with the sheath to the little finger and thumb respectively. The sheath to the second, third and fourth fingers stops just proximal to the metacarpophalangeal joints. The ulnar and radial bursa may communicate either directly or through an intervening bursa in the palm.

palmar incision midway between the fingers with the incision distal to the flexion creases in the palm. Such an incision might give some drainage of the palmar or thenar space, but if one of these is distended with pus the connecting channel along the toes we have a crack or break, through which organisms gain an entrance with infection in the web. The most satisfactory treatment is drainage in the acute stage. If there is a persistent sinus this should be opened widely or excised, and the corn

should be excised when the infection is under control.

Palmar Space and Thenar Space. These

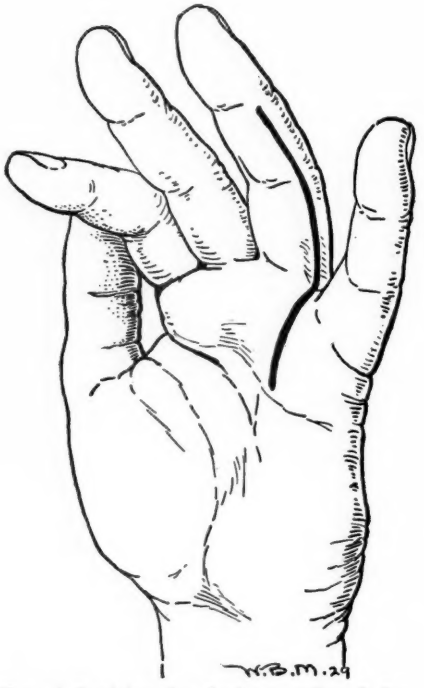

Fig. 6. Incision for drainage of an infection in the flexor tendon sheath of the fourth finger. If the sheath is opened throughout its length the finger must be kept in extension to prevent prolapse of the tendon. No drains should be inserted against the tendon.

potential roughly triangular spaces which normally may be filled with loose areolar tissue lie deep to the tendons in the palm, volar to the bones and interosseous muscles, the palmar space to the ulnar side of the third metacarpal bone, the thenar space to the radial side of this bone. Each has its apex just distal to the carpal ligament, its base about on a line joining the distal end of the middle flexion crease with the proximal end of the distal flexion crease. At times a prolongation may extend out along one or more lumbrical muscles. These spaces may be infected through a puncture wound, by lymphatic extension or by extension from the tendon sheaths or from a web space abscess. If early drainage is not instituted infection in one of these spaces may extend to the other.

The diagnosis of a thenar or palmar space abscess is made by the location of the throbbing pain and extreme tenderness on pressure along with other signs of acute inflammation. There may be in addition pronounced lymphedema of the dorsum of the hand but without induration or point tenderness.

If there is extension along a lumbrical muscle there may be evidence of a web space infection. (Fig. 3.) In the case of the palmar space abscess there is little evidence of swelling in the palm of the hand due to the rigidity of the palmar fascia, but the palm may lose some of its concavity. The thenar space abscess, on the other hand, produces a marked ballooning of the space between the thumb and index finger both on the dorsal and volar aspect. (Fig. 4.)

Treatment is by surgical drainage. The palmar space is opened by an incision in the palm, either between the third and fourth or the fourth and fifth fingers, depending on which shows the greater evidence of extension along the lumbrical canal. When there is a choice the incision between the fourth and fifth fingers should be avoided since it offers the risk of accidentally opening the ulnar bursa. This must, of course, be carefully guarded against. Occasionally it may be necessary to drain through both of these spaces. The incision is made in the distal part of the palm to avoid the vascular arches and midway between the fingers to avoid the tendon sheaths, vessels, and nerves, to the fingers. From this incision a hemostatic clamp is passed along the lumbrical canal into the collection of pus and the drainage tract enlarged by spreading the clamp and withdrawing. Here also care must be observed to avoid injury to a tendon sheath which lies to either side of the incision or a bursa which lies volar to the abscess.

The thenar space may rarely be opened in a similar manner between the index and middle finger when there is an extension into this web space. Usually, however, the thenar space abscess is approached through

an incision on the dorsum of the web between the thumb and index finger. (Fig. 4.) A clamp is inserted along the palmar surface of the adductor pollicis muscle to enter the thenar space and is spread to provide free drainage. Occasionally the pus may dissect between the transverse and oblique bellies of the adductor pollicis muscle to reach the dorsum of the web space. In either case the drainage tract is enlarged by spreading and withdrawing the clamp. Needless to say, in all cases free drainage through an adequate incision is imperative since the larger incision heals quicker with less damage to tissue than the small incision with inadequate drainage.

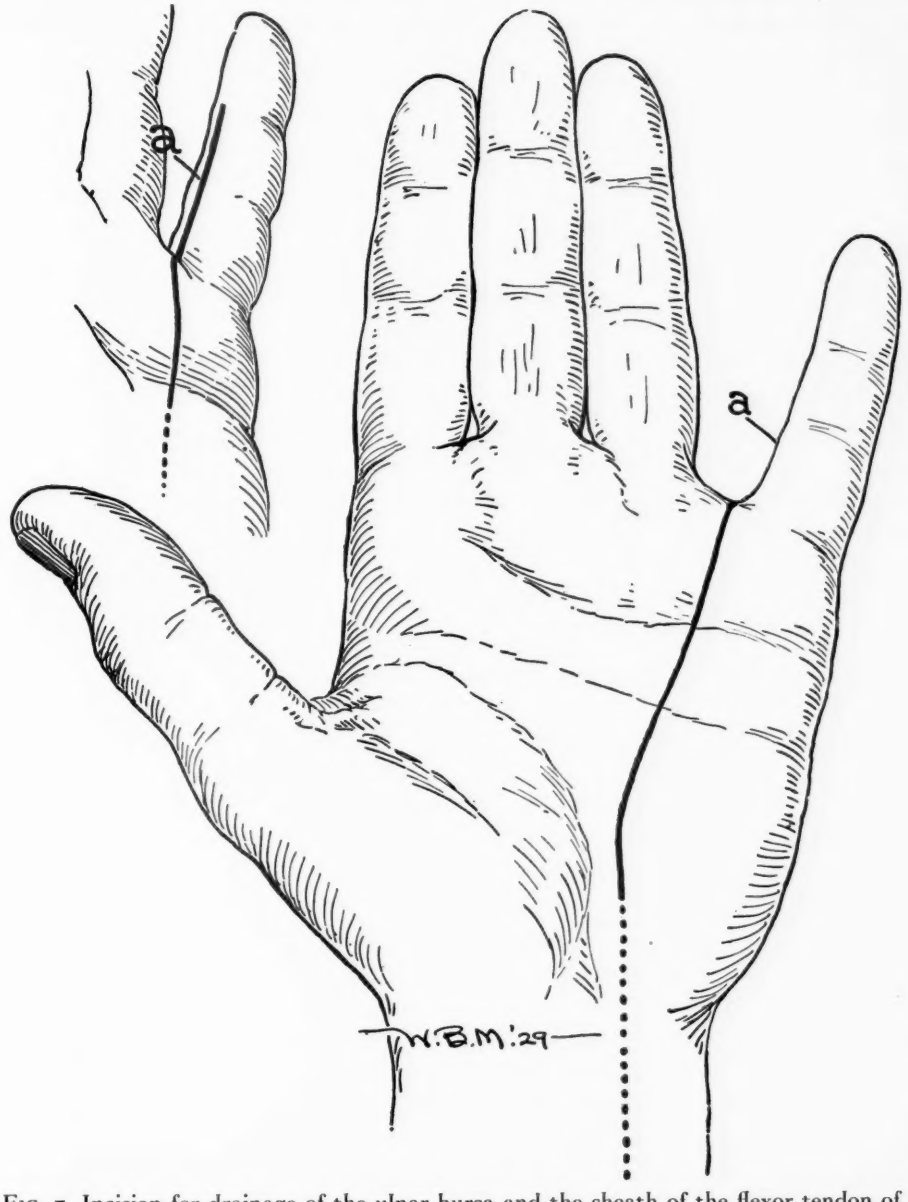

Fig. 7. Incision for drainage of the ulnar bursa and the sheath of the flexor tendon of the little finger. This incision can be carried through the annular ligament if it seems desirable in order to give free drainage of infection above the wrist. However, when this is done the wrist must be kept in extension to prevent prolapse of the tendons. This extension above the wrist is indicated by the dotted line. *a* shows the incision on the side of the little finger for drainage of the sheath.

Tendon Sheaths. The tendon sheaths in the hands are of greater surgical signifi-

cance than those in the feet, due first to their more frequent involvement, and second to the wider variety of motions and of the wrist, and rarely become infected. On the palmar surface we have the tendon sheaths to the second, third, and fourth

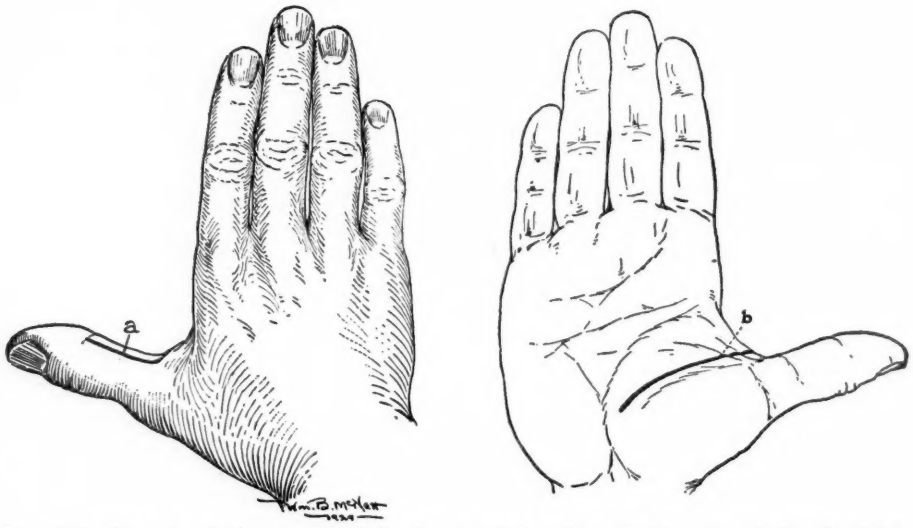

FIG. 8. Incision for drainage of an infection involving the radial bursa and sheath of the flexor pollicis longus tendon. *a* shows the incision on the side of the thumb, *b* the incision as it extends across the palm. This incision must stop at least 1 cm. short of the annular ligament in order to avoid injury to the motor branches of the median nerve, which supply some of the muscles of the thenar eminence. If the infection extends above the wrist this must be drained through appropriate incisions in the forearm.

uses to which the fingers and hand are adapted. In view of this fact the primary consideration will be given to the hand. However, one must keep in mind the sheaths in the foot as the route of extension of inflammation. This applies particularly to the sheath of the long flexor of the great toe which extends along the sole of the foot, passes behind the internal malleolus and to the dorsomedial aspect of the lower leg and may or may not be continuous over this distance. This channel of extension should be kept in mind in treating gangrene of the great toe or any infection in this region. When the toe is to be amputated in the presence of infection, suitable precautions must be taken to close off this sheath and to prevent the retraction of the contaminated cut end of the tendon. When it becomes infected, incision and drainage with the removal of hopelessly damaged and sloughing tendon is indicated.

In the hand the sheaths for the extensor tendons are short, superficial, in the region fingers which extend from the insertion of the tendon in the distal phalanx to a point just proximal to the line of flexion of the metacarpophalangeal joints. The sheaths of the flexor tendons of the little finger and thumb, however, are usually continuous with the ulnar and radial bursae respectively. (Fig. 5.)

The radial bursa surrounds the flexor pollicis longus tendon, extends through the palm, beneath the annular ligament and into the forearm. The ulnar bursa partially surrounds the flexor tendons to the fifth, fourth, usually the third, and occasionally the second finger in the palm. It is usually, but not necessarily, connected with the tendon sheath of the fifth finger but not the others. There may be a communication between the radial and ulnar bursae in the palm, either direct or through an intervening small bursa. This anatomic arrangement permits a wider spread of infection and makes all infections in the thumb and little finger potentially more likely to

result in extensive damage to the hand than a similar infection on either the second, third or fourth finger.

Diagnosis is concerned primarily with the location of the infection since its presence is evident. Tendon sheath involvement is determined by the diffuse swelling of the finger, point tenderness along the course of the tendon sheath or bursa, absence of active motion, the involved finger being held in moderate flexion, and severe pain on passive motion, either flexion or extension. The tendons in the adjacent uninvolved sheaths may show some limitation in motion but slight motion elicits relatively little if any pain.

Treatment. The most important single factor in treatment is early diagnosis, with early drainage before irreparable damage has been done. The type of infection is also of great importance in determining the extent of the destruction. This to a large degree is beyond the control of the surgeon, but he can use every precaution to limit secondary infection in his drainage incisions.

Incisions for drainage should be placed on the side of the fingers and not in the midline. (Fig. 6.) Care should be taken to avoid injury to the lateral nerves and blood vessels. The finger should be kept in extension to avoid prolapse of the tendon. The incisions should be adequate to insure free drainage and no drains should be inserted so as to come in contact with the tendon.

The ulnar and radial bursae must be opened up into the palm. The incision of the ulnar bursa may be carried up through the annular ligament (Fig. 7) but this cannot be done in the case of the radial bursa (Fig. 8) since the motor branches of the median nerve to the thenar eminence will be divided and the power of opposing the thumb to the fingers will be lost. The extensions of the radial and ulnar bursae above the wrist are predominantly posterior to the tendons and these can be drained by a lateral incision just anterior to the bone on either or both sides of the forearm just above the wrist. Care must of course be taken to avoid injury to the vessels, nerves and tendons. Occasionally there may be a pocket of pus anterior to the tendons above the annular ligament, which may be drained through an anteriorly placed incision. Needless to say that in any of these cases hopelessly damaged tendons should be removed to hasten healing. Tendon transplants can be tried later in suitable cases by one experienced in such work

As soon as the acute infection has subsided and there is no longer danger of prolapse of the tendons, passive and later active motion should be used. As soon as healing is complete, baking, massage, active and passive motion, traction, etc., should be instituted and persisted in for an indefinite period of time or until full function is restored. It should be emphasized that these patients should not be treated except by a person of wide experience in infections of the hand and then only if he has available every facility for the restoration of function. Even under the best of conditions the results may be poor.

Deep forearm infections usually result from an extension of an infection in the radial or ulnar bursae or rarely the palmar or thenar space. The pus is located anterior to the bones, interosseous septum and pronator quadratus muscle, and beneath the tendons. It may dissect up the forearm, reach the loose tissue about the median nerve or the ulnar nerve and artery and follow a course along these either up or down the arm.

A deep forearm abscess is best drained by a lateral incision passing just anterior to the ulna a few centimeters above the styloid process. An incision can then be made with greater safety on the radial side if through and through drainage is considered advisable, by passing a hemostat through and incising on the point. Care must be taken to avoid injury to the nerves and arteries, the incisions being posterior to these structures.

Pyarthrosis is treated as such a condition elsewhere by early free drainage, avoidance of drains into the joint, maintenance of mobility of the joints if possible, and traction to minimize damage to the articular surface.

Osteomyelitis is also treated on the same general principles as apply elsewhere; that is, by early free drainage, with the minimal trauma, general measures to increase the resistance of the patient, transfusions, antitoxins when available, and chemotherapy with sulfanilamide or related drug when indicated. After drainage is established and the acute condition is over it is best to await separation of the sequestrum. After this has separated and is no longer needed to maintain the shape of the part it should be removed, and the wound allowed to heal.

In the hand or foot osteomyelitis and pyarthrosis are frequently associated and are likely to result in prolonged illness and serious permanent disability. In the small joints there may be loss of mobility and the parts should be kept in the best position for function. At times when the stiff, deformed digit is more of a handicap than an asset it may be wise to remove it. If the small bones and associated joints of the wrist or ankle are involved, the condition is difficult to cure, follows a prolonged course, should have free drainage, may require removal of many or all the small bones or eventual resection of the joint. Care should be taken to see that the joint is kept in the best position for function. Such infections demand the most skilled care, diagnosis should be made or suspected at the earliest possible time and the case placed in the hands of one experienced in handling such conditions. Space does not permit a full consideration here.

ACUTE OSTEOMYELITIS

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ACUTE hematogenous osteomyelitis is essentially a disease of the growing period, occurring most frequently in children between the ages of 3 and 16. Because of its high mortality rate and frequent crippling aftermath, acute osteomyelitis in children is one of the most serious surgical conditions encountered and one in which early diagnosis and treatment are of paramount importance. Much has been written on the subject and most writers are unanimous in their conception of the etiology, pathogenesis and pathology of the disease. In the past few years, however, because careful analyses of a large series of cases from many clinics have revealed an alarmingly high mortality rate, different methods of treatment have been advocated. As a result of this, a certain amount of confusion exists today in the minds of the medical profession in regard to the most efficacious method of handling acute hematogenous osteomyelitis. Naturally, as there are a great many variables present, it is impossible to generalize about the treatment. However, a few uncontradictable facts have been assimilated which should help in the management of this condition and appreciably reduce the mortality rate.

Etiology. The causative organisms are predominantly the staphylococcus and the streptococcus and much less frequently the pneumococcus, colon and typhoid bacilli. Statistics from a large number of clinics show that the staphylococcus is the invading organism in from 69 to 90 per cent of the cases. In a series of thirty cases studied at the Henry Ford Hospital, twenty-six, or 86 per cent, were due to the staphylococcus. According to Green,[1] in osteomyelitis seen in infants under 2 years of age the streptococcus is encountered more frequently than the staphylococcus in a ratio of about 2:1. The primary source of infection is often difficult to determine, although in many instances a history may be obtained of a preceding skin infection such as a boil, wound or abrasion. In other cases the bone lesion may occur as a sequel to middle ear infection, acute tonsillitis or abscessed teeth. As a result of bacteremia or septicemia, the organisms are conveyed to the bone, usually to the metaphysis of a long bone. The flat bones, such as the ilium and skull, and the short bones of the hands and feet are less frequently involved.

Pathology. The pathologic concept that is almost universally accepted is an initial infection in the metaphysis of a bone conveyed there by the blood stream. It has been suggested by some writers[2,3] that the term "acute hematogenous metaphysitis" more accurately describes the pathology. There are several factors that probably account for the localization of the bone lesion in the metaphysis rather than in the medulla. Experimental work by Teruo Hobo,[4] Robertson,[5] and others has demonstrated that there is a lessened power of phagocytosis or an absence of it at the metaphysis. In addition, it has been shown that there is a large venous bay in the metaphysis which permits marked slowing of the blood stream. The organisms produce local bone necrosis and the abscess so formed spreads rapidly in the line of least resistance—usually toward the periosteum. Pus then usually spreads under the periosteum, stripping it from the bone and often extends the entire length of the shaft. Relief of tension of the abscess is obtained either by spontaneous rupture of the periosteum or by surgical drainage. That portion of the shaft that has been deprived of its circulation dies and the dead bone is gradually separated from the living bone, forming a sequestrum. Under the raised periosteum, new bone known as the involucrum is laid down. The sequestrum

is either extruded spontaneously or removed surgically.

Robertson[5] has emphasized the fact that because of the exotoxin produced by the staphylococcus, osteomyelitis caused by this organism is a much more serious condition than that caused by the streptococcus. The toxin not only produces bone necrosis but causes serious changes in the vascular system. He points out that if the individual possesses an inadequate amount of natural antitoxin, the disease is likely to prove overwhelming unless adequate combative measures are used.

Symptoms. The first symptoms complained of are usually pain and stiffness in the region of a joint. A history is frequently given of a recent injury to the involved area. Within twenty-four hours the pain becomes very severe and the temperature is elevated, often to 103°F. and higher. There is an accompanying leucocytosis ranging from 10,000 to 25,000. These children are frequently extremely toxic and exhibit all the signs of an acute blood stream infection. Careful local examination in the early stages will reveal the point of maximum tenderness to be in the neighborhood of the epiphysis and not over the joint. The joint can be moved without undue pain if motion is carried out carefully. Later when the periosteum and soft tissues have become involved there is, in addition, swelling, redness, edema and often fluctuation.

The blood culture is frequently positive for staphylococcus or streptococcus. Robertson has stated that if cultures are taken at frequent intervals, blood stream infection can be demonstrated in every case of acute hematogenous osteomyelitis.

Symptoms of acute osteomyelitis in the adult are usually quite different from those in the growing child. The onset of symptoms is much more gradual and the patient is rarely as acutely ill. The localization of the lesion, instead of in the metaphysis, is usually in the shaft of a long bone and frequently in the mid-portion. Symptoms of pain and tenderness on pressure may be present for days or even weeks before signs of a general reaction supervene. *X*-ray evidence of bone infection is late in appearing and a diagnosis of osteomyelitis is extremely difficult to make unless one has in mind the possibility of such a condition. Temperature elevation, leucocytosis and a moderate degree of toxicity usually supervene after a week or two of milder symptoms. Often, coincident with the appearance of these symptoms, there will be roentgenologic evidence of bone involvement.

Treatment. Until recent years the opinion of medical men and surgeons was almost unanimous in regarding acute osteomyelitis as an emergency and early operation was the universal method of treatment. The type of operation varied according to the merits of the individual case and the preference of the surgeon. The procedures of choice were: incision of the periosteum, multiple drill holes into the metaphysis or guttering of this area. The operation of diaphysectomy has long been discarded as being unnecessary and too mutilating.

Because of a mortality rate that has remained persistently high regardless of or because of too early surgery, more conservative treatment is now being advocated by many surgeons. It is argued that the bone focus represents merely a local manifestation of a general infection and that treatment should be directed toward raising the patient's resistance. The abscess is allowed to rupture spontaneously or incision and drainage of the soft tissue abscess are done when the child's condition warrants such a procedure. Wilson and McKeever[6] report a mortality rate of 25 per cent in a group of twenty-four patients treated by early operation and only 9.7 per cent in a comparable group of thirty-one patients in whom drainage was done from the seventh to the twenty-eighth day of the illness. Crossan,[7] on analyzing 121 cases, found a mortality rate of 35 per cent with operation in the first week, in contrast to 3 per cent in the second week and 15 per cent in the third. Pyrah and Pain[8] made similar observations on a series of some 260 cases studied and stated: "Incision into an

area in which such unlocalized, perhaps rapidly spreading inflammation is present, will on the one hand give exit to toxic material and to accumulating inflammatory debris, but on the other hand it must inevitably open up tissues which can allow of the rapid absorption of toxic material by veins and by lymphatics into the general circulation."

Each method of treatment undoubtedly has merit, but in dealing with a condition presenting as many variations as acute osteomyelitis, it is impossible to generalize about the manner of attack. The type of treatment indicated varies with many factors, including the age of the patient, duration of the lesion and degree of toxicity present. Early operative treatment in certain cases may be the means whereby much bone destruction and future disability is prevented whereas in other cases early operation is definitely contraindicated and constitutional measures are far more important. The method of treatment that appears to be best indicated will be discussed according to the age levels.

1. *Acute Osteomyelitis in Children under Two Years of Age.* Green[1] and Ober[9] have recently demonstrated that acute osteomyelitis in infants is a different problem from the same disease in children over 2 years of age. The predominating organism encountered in the former group is the streptococcus. The abscess extends rapidly from the metaphysis to the cortex and perforates the thin periosteum, forming a localized abscess in the soft tissues. These children are usually very toxic and measures to combat the constitutional disturbance are of primary importance. Dehydration, which is almost constantly present, is controlled with intravenous fluids. Transfusion of small amounts of blood, given daily or every other day, is undoubtedly beneficial. Sulfanilamide is indicated in this group since in the majority of cases the streptococcus is the causative organism.

As soon as the child's condition warrants it, the abscess is opened under anesthesia, the pus is evacuated and a vaseline pack is inserted loosely in the wound. No attempt is made to open the bone. Dry dressings are placed over the wound and a plaster of Paris cast is applied to the extremity. The cast may be windowed and dressings done at intervals of from one to two weeks. The wound usually heals in from two to three months and sequestrum formation is extremely rare. After a period of from one to two years there is usually complete restoration of the contour of the bone.

Green reports that since the adoption of this type of treatment in infants the mortality rate has been reduced from 21 per cent to 5 per cent.

2. *Acute Osteomyelitis in Children over Two Years of Age.* Treatment of acute osteomyelitis in this group varies with the condition of the child when first seen. Generally speaking, if the child is quite toxic, dehydrated and has a temperature elevation of 103 degrees or over, operation should be delayed and supportive measures undertaken. The mortality rate in this group with too early surgery and and disregard of the child's general condition has been appallingly high.

Dehydration should be combated with large quantities of fluid by mouth or by the intravenous route. Small blood transfusions daily or every other day are indicated. If the blood culture is positive for streptococcus, sulfanilamide may be used. If, as is true in about 80 per cent of this group, the staphylococcus is the causative organism, staphylococcus antitoxin will often aid in decreasing the toxicity of the child and perhaps prevent metastases. This preparation has not been used extensively enough yet to warrant any definite conclusion, but indications are that it will prove an important adjunct to the treatment of staphylococcal osteomyelitis. The antitoxin is given intramuscularly in doses of 30,000 to 150,000 units.

When the child's general condition warrants it, which may be in from a few days to two weeks after the onset, the abscess may be drained. Surgery even at this time should be minimal and incision of the soft tissues or of the periosteum is usually all

that is necessary. The wound is gently packed with vaseline gauze and the extremity is immobilized in a splint or encased in a plaster of Paris cast. The wound may be dressed at intervals of from one to two weeks and at a later date when sequestration is complete, a second operation may be performed for removal of dead bone.

If the child is seen a day or so after the onset of symptoms, is not toxic and the temperature range is below 103°F., early operation, in the writer's opinion, is the method of choice. The operation is done preferably with the use of a tourniquet and the bone is approached by the most accessible route, avoiding any undue trauma to the soft tissues. If pus is not encountered under the periosteum, drill holes are made through the cortex in the direction of the metaphysis, with care not to damage the epiphysis or enter the medulla. Often several such drill holes are necessary before pus can be seen escaping under pressure. A small window of bone is then removed with a thin sharp osteotome, exposing the abscess cavity, which should not be curetted. Vaseline gauze is packed loosely in the wound and the extremity is immobilized in a splint or a plaster of Paris cast.

Early drainage of the bone focus is undoubtedly an ideal procedure if the child's physical condition warrants it. Unfortunately, in the majority of cases the child is seen late, at which time the general condition precludes early surgery. In ideal cases, however, by early operation, subperiosteal spread of the abscess is prevented, toxic absorption and destruction is minimized, metastases and, in many cases, sequestrum formation is prevented, or if present, is minimal.

3. *Acute Osteomyelitis in Adults.* Acute osteomyelitis in the adult is seen quite rarely and, as mentioned above, the clinical picture is quite different from that seen in children. The process is slower and roentgenograms may not show bone changes for from two to four weeks from the time of onset. The lesion is usually in the shaft and is rarely in the metaphysis. As soon as the diagnosis has been established, the bone should be exposed through the most accessible route over the involved area. Drill holes should be made through the cortex to determine accurately the location of the abscess and a window is then lifted from the bone to permit adequate drainage. The wound is packed with vaseline gauze and the extremity adequately immobilized. Healing is usually slow, often taking from three to six months, but sequestrum formation is rare and recurrence is seen less frequently than with osteomyelitis in children.

SUMMARY

Acute osteomyelitis is a serious surgical condition that, because of its high mortality rate, warrants the most careful consideration before operation is performed. Treatment, to a large extent, must be individualized and factors such as the patient's age and general condition, the degree of toxicity, and duration of the lesion are important in determining when surgical drainage may be most advantageously done. If proper consideration is given to these factors and each case treated according to its individual merits, the mortality rate will be appreciably reduced.

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COMPOUND FRACTURES

WITH SPECIAL REFERENCE TO THE LOWER EXTREMITY

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ALTHOUGH accurate data are lacking otherwise, the results in death and disability after compound fractures are shown very well by the statistics of the war of 1914 to 1918. In compound fractures of the thigh and leg particularly, the number of war wounded dead or permanently disabled, five years after our military experience, was shown by the Surgeon-General's report to be far larger than it should have been. It is sometimes claimed that peacetime injuries are less severe and results obtained in civil practice much better. A careful study of the patients in almost any hospital will show that they not only do no better but often do worse than those described in the Surgeon-General's Report.

Following my own military experience in 1917–1919 I called attention[1–5] to the necessity for better primary reduction and immobilization in these compound bone and joint injuries. Unfortunately, the atmosphere surrounding treatment for compound fractures was clouded during and after the war period by attempts to apply various so-called "war lessons" to these patients. Supposed "improvements" included constant irrigation of compound fracture wounds, early mobilization of joints in the vicinity of fractures, modifications of standard splints, and other details of technique, all tending to render less efficient splint methods suggested by Sir Robert Jones and others who had become expert in dealing with war injuries and in preventing disability and deformity.

Even the teachings of Lister with regard to compound fracture wounds were forgotten in the supposed discoveries of the war period. Actually, the results of treatment in compound fractures were not so good during the Great War as those demonstrated to us by Lister in his first cases treated with carbolic acid fifty years before. Moreover, the fundamentals of fracture treatment—primary reduction and immobilization in correct position—were forgotten in most cases, in attempts to cure septic wounds by frequent irrigations, to maintain motion by joint movements, to refine transportation splints, and in experiments with other details of treatment.

At the present time we are still in confusion as to the handling of compound fractures. There have been so many attempts to discover a chemical cure for septic wounds, to modify splints and to provide special gadgets to control these patients, that the fundamentals are neglected or all but forgotten. Besides, the old teaching that every patient is an individual problem to be solved only by the particular surgeon who is attending him at the moment, is one that should have been exploded long ago. The fact is, that the same principles and to a very large extent the same details of treatment may be applied in every case of compound fracture if certain important facts are kept in mind.

This is a point to which this writer has called attention for the past twenty years. Numerous papers[6–12] have pointed out that primary reduction and immobilization in correct position are the two things necessary in all cases of fracture, simple or compound. Also, now that we know that frequent dressing of the wound is unnecessary, suitable simple splints and casts are sufficient to attain these objects in every fracture case.

These points in treatment, including infrequent dressings, have been accepted by hundreds of surgeons all over the world. There is a large mass of literature which shows the tendency in that direction. The

recent publications of Dr. J. Trueta, formerly of Barcelona, indicate how successful the application of these simple rules may be even in gunshot fractures, as they were handled under war conditions in Spain. Dr. Trueta has published a report of more than 1,000 gunshot fractures, including the femur and leg, with only six deaths in the entire series. These were all treated by the plan of primary reduction, immobilization in plaster of Paris casts, drainage of the wounds by means of vaseline or other simple packs and infrequent dressing.

In response to many recent letters and for the first time in several years, I shall submit a description in detail of our own exact technique in dealing with compound fracture cases. These methods apply to all cases, no matter in what part of the body the compound bone injury is situated, and in early or late treatment. New drawings or diagrams are submitted to clear up some of the points in regard to which numerous inquiries have also been received.

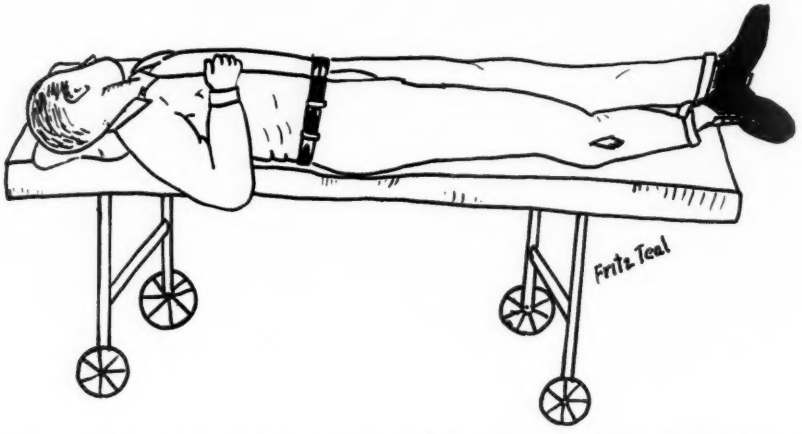

Fig. 1. The patient arrives at the receiving room from the ambulance—usually without a splint.

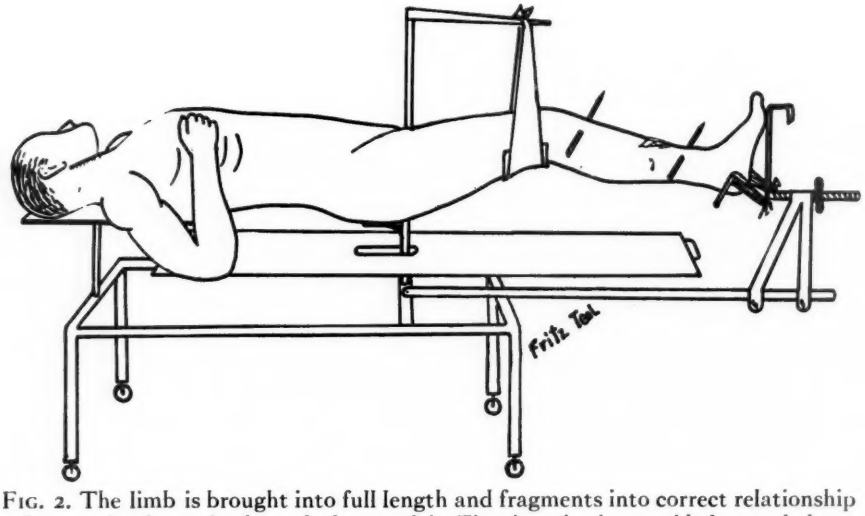

Fig. 2. The limb is brought into full length and fragments into correct relationship by traction by a pin through the os calcis. Fixation pins inserted below and above fracture when necessary.

First, the compound fracture patient, whether a recent case or one brought in for treatment following prolonged infection, drainage, deformity or disability, is placed upon the fracture table. With suitable preparation in the way of sedatives, fluids,

serums, etc., immediate adjustment of the patient and his extremities is made on the operating table. This is done in such a way that the injured limb is brought into full length, correct anatomic relationship of all the parts, and proper rotation of the distal portions of the extremity. In more than 90 per cent of all cases, early or late, this can be accomplished with very little difficulty. With *adequate traction* very little manipulation will be required to put all the injured parts in correct position.

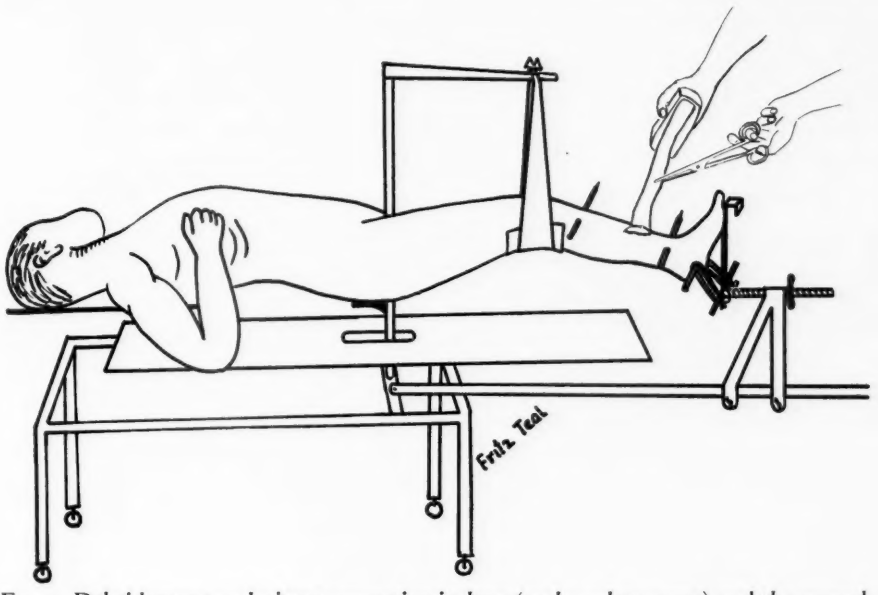

Fig. 3. Debridement or drainage operation is done (early or late cases) and the wound packed lightly to the bottom with vaseline gauze. Dry cotton gauze pads are bandaged on.

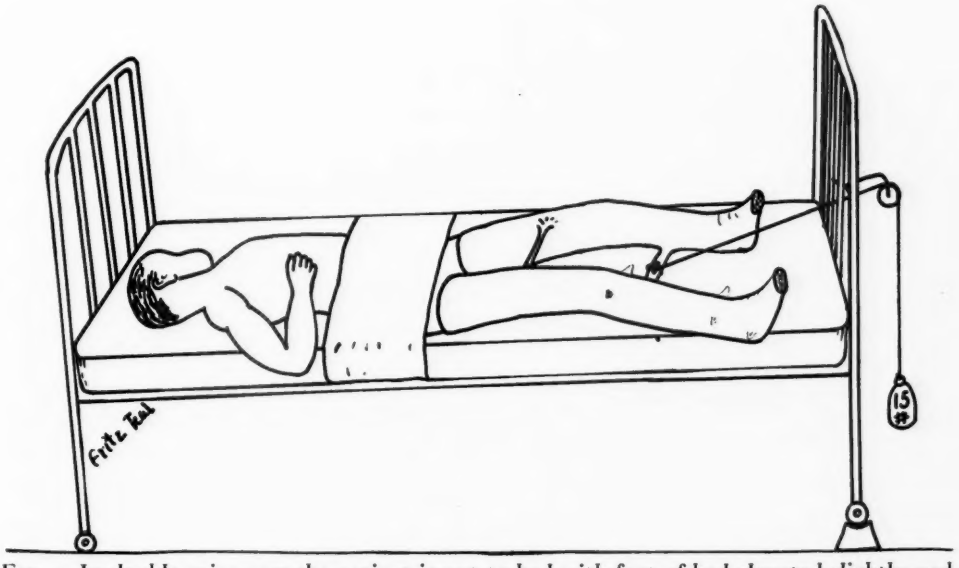

Fig. 4. In double spica cast the patient is put to bed with foot of bed elevated slightly and 10 to 15 pounds of weight attached to the cross bar. Patient is to be turned on the face three or four times each twenty-four hours. No windows in the cast or dressings until healing is well established.

Emergency length and position having been secured, plans are made at once for making this position permanent. One must provide for fixed traction in the subsequent splint or cast. When necessary, pins are passed through the limb distal to the fracture, and then proximal to the fracture. The original pull should often be made upon a pin through the heel or one of the metatarsal or metacarpal bones. These pins must be moderately heavy and must be such as will remain in position without becoming loose or causing irritation.

If ice tongs or wires are used and especially if weight and pulley traction are applied to these after the operation, loss of position, with irritation about the pins or wires is almost certain to occur. In our cases, subsequent permanent fixed traction is obtained by the application of the plaster of Paris cast to include the limb and the pins. A rule you will remember is that skeletal fixation devices, if allowed to wobble at the ends or at the portions outside the limb, will certainly become loose in the bone and cause irritation, necrosis and infection in the bone and at the points of entrance and exit in the skin. If the patient, the limb, and the skeletal fixation devices are all immobilized in the cast, no such complications will occur.

After the wound at the point of fracture has been provided with suitable drainage, either with a vaseline pack or in some other way (debridement, of course, having been done as a preliminary) the patient is placed in the permanent plaster of Paris cast. For almost twenty years with us, this has been a double plaster of Paris leg cast or spica.

Following his visit to us in 1927, Dr. Roger Anderson devised an apparatus for this purpose and called the method "well leg traction." This is not a good term because fixation of the well leg contributes very little to the traction. This traction, by our plan, is really intrinsic in the cast on the injured limb, but the double cast does provide better control by means of a cross bar for the injured limb and the patient.

My own original suggestion regarding this method came from the double abduction splints of Hugh Owen Thomas and Dr. Bradford of Boston, who had used them for many years.

The fixation pins, having been caught in the plaster of Paris cast and both limbs having been included in the plaster with a cross bar between, the traction on the foot at the lower end of the table may be released. The illustrations show that no loss of length or position can occur. The feet are then included in the cast. This makes the patient more comfortable and adds to the immobilization of all the injured parts.

After the patient is put to bed a weight and pulley traction on the cross bar between the limbs adds further to his comfort, because it prevents spasm about the thighs and hips and helps relaxation.

No windows are made in the cast and no dressings are necessary. The injured limb and the wound should be let alone until healing has progressed to the point where both the fracture and the patient are safe from the complications that might otherwise occur.

If the patient does develop pain, interference with circulation, or swelling in the limb, rise of temperature or increased white cell count, these must have consideration as in any other surgical case. However, to tear off splints or casts or to start antiseptic irrigation of an already properly drained compound fracture wound is entirely wrong. The only indications, as a rule, are to release constriction if necessary, or to provide drainage at the original wound or elsewhere. Then let wound and patient alone for gradual recession of symptoms—which will always occur.

The after-care of our patients is actually as simple as that. After some weeks or months they are taken to the operating room, an anesthetic is administered, pins are taken out, the cast is removed and such a revision of position is done and such a dressing applied as may be necessary for a satisfactory final result.

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Rhazes . . . was perhaps one of the first men to use sutures of animal gut for the repair of abdominal wounds. It may have been his early musical training which suggested the diversion of harp-strings to this end.

The brief excerpts in this issue were taken from "The Story of Surgery" by Harvey Graham (Doubleday-Doran).

BOOK REVIEWS

THE SURGERY OF PAIN. By René Leriche, M.D., F.R.C.S. Translated and edited by Archibald Young, Regius Professor of Surgery, University of Glasgow. Baltimore, 1939. Williams & Wilkins. Price $6.50.

This book is different. It will be read and reread and much pondered over. Readers may disagree with the author in minor matters, but the average surgeon will have at least some of his viewpoints changed as he reads.

Leriche is probably the one man responsible for the pioneer work in the surgical alleviation of pain. He began during the World War when he was particularly interested in victims suffering from causalgia. His experimental and surgical work at Strasbourg and Lyons carried him into research on the neural and vasomotor causes of pain and into procedures for its relief.

The present volume represents lectures given in connection with the chair of medicine at the Collège de France. It has been brilliantly translated by Archibald Young, who has rendered the spirit as well as the letter of the French into fine English prose. In his preface, Professor Leriche says that his lectures "are devoted to the study of pain from the point of view of a surgeon. . . . The author's aim has been to investigate the problem of real, or *living* pain, as seen through the ever changing mirror of the clinic, and removed as far as possible from the cold abstractions of book doctrine."

As we said in the beginning, this book is different. We hope that it will find its way into the hands of many, many surgeons.

MENSTRUAL DISORDERS: PATHOLOGY, DIAGNOSIS AND TREATMENT. By C. Frederic Fluhmann, M.D., Philadelphia, 1939. W. B. Saunders.

The general practitioner probably meets with as many women suffering from menstrual upsets as does the gynecologist. He must know, as must the latter, of the great changes in concepts of the physiology, pathology and treatment of these disorders which have taken place in recent times. Therefore the publication of this concise, to the point book (329 pages) is particularly well timed.

Much space and emphasis are given to the important field of the endocrines, but the subject as a whole has been viewed as a general problem. The author gives detailed treatments directed to basic causes where these are known, and also suggests methods for symptomatic relief.

Gynecologists will find the work interesting, but we hope that this book will be read by the multitudes of practitioners of general medicine who can gain definite knowledge of diagnosis and form intelligent bases for treatment. There is no longer any excuse for prescribing the first hormone or combination of hormones that comes to mind.

THE CLINICAL AND EXPERIMENTAL USE OF SULFANILAMIDE, SULFAPYRIDINE AND ALLIED COMPOUNDS. By Perrin H. Long, M.D. and Eleanor A. Bliss, SC.D. New York, 1939. Macmillan. Price $3.50.

Six years have passed since Foerster first reported upon the use of prontosil. In the intervening time we have witnessed the conquest of streptococcal, meningococcal, gonococcal, pneumococcal, and many other types of infections by means of chemotherapy. The volume of reports upon the various aspects of the new bacterial chemotherapy is enormous, and because of this the summary presented in this new book is especially needed. Although much has been learned in the control of bacterial infections, it is apparent that much remains to be done.

The contents of the book include a historical sketch of sulfanilamide therapy, a study of the chemotherapy of experimental bacterial infections, experimental toxicity, and analysis of the comparative pharmacology of sulfanilamide and its allied compounds. The modes of action of sulfanilamide and its derivatives, the clinical use of this drug and of sulfapyridine, etc., receive detailed discussion. The wide applicability of the drugs makes the subject of almost universal interest in medicine.

A Textbook of Bacteriology. By Hans Zinsser, M.D., and Stanhope Bayne-Jones, M.D. Eighth Edition. New York, 1939. D. Appleton-Century. Price $8.00.

The first edition of this standard work appeared in 1910. Now, in 1939, the eighth edition appears. What can a reviewer write that has not already been written concerning this perfect Textbook? The authors, men of international reputation, have kept the work abreast of the scientific times. No one can criticise the text-matter. This is the subject of bacteriology brought into complete and useful form.

A Textbook of Surgery. By American Authors. Edited by Frederick Christopher, M.D., F.A.C.S. Second Edition. Philadelphia, 1939. W. B. Saunders.

The editor, in the preface, states, "The dominant plan of this textbook is to give the student a concise presentation of surgery which is characterized by the maximum authority." In 1695 pages the contributors (over 110 in number) have presented only tested and accepted present day principles in surgery, omitting all debatable and incompletely tried methods. The entire range of the surgical field has been covered. There are 1381 illustrations, important references listed at the end of each chapter, and an exhaustive index.

Royal Northern Operative Surgery. By the Surgical Staff of the Royal Northern Hospital. London, 1939. H. K. Lewis & Co. Price £2.2.0.

Eleven surgeons of the Royal Northern Hospital have written a book which is designed to represent as far as possible the practice which is followed in the Royal Northern Group of Hospitals. The special subjects have been omitted, and to make the work as practical as possible, classical procedures and those that have passed out of common use have not been described. As a rule, one well-tried way of performing any given operation has been presented. The aim has been to produce a live surgery to help and refresh the practicing surgeon. In accordance with this aim, the book is concise, well written, amply illustrated.

Diseases of the Nose and Throat. By Charles J. Imperatori, M.D. and Herman J. Burman, M.D. Second Edition. Philadelphia, 1939. J. B. Lippincott.

The relationship of allergy to rhinology in general and to polyposis in particular has been stressed in the new edition of this work to conform to the present trend. The authors have added to the section on the nose a discussion of dermoid cysts, telangiectasia, injuries, the cytology of nasal secretions, and fractures of the nasal sinuses. They have rewritten the chapter on orbital infections as a complication of sinusitis.

The work shows careful writing. The illustrations, 480 in number, are excellent.

Peripheral Vascular Diseases: Diagnosis and Treatment. By William S. Collens, M.D. and Nathan D. Wilensky, M.D. Springfield, 1939. Charles C. Thomas. Price $4.50.

Within recent years much scientific interest and new research has been devoted to the peripheral vascular diseases. Dr. Collens and Dr. Wilensky therefore present a concise authoritative résumé of the facts on peripheral circulation, embodying the surveys and extensive experimental work done, as well as detailing the clinical literature and supplying practical information on the diagnosis and treatment.

Pye's Surgical Handicraft. Edited by Hamilton Bailey, F.R.C.S. Eleventh Edition. Baltimore, 1939. Williams & Wilkins. Price $6.00.

It is fifty-four years since Pye's Surgical Handicraft first appeared. Surgical procedures and technique, especially minor surgery, have changed greatly with the passing of time. In this the 11th edition, Hamilton Bailey, keeping to the original purposes and aims of the author, has made the work modern in every way. The title page reads, "A Manual of Surgical Manipulation, Minor Surgery, and Other Matters Connected with the Work of House Surgeons and of Surgical Dressers." This is as good a description of what the book is about as one can wish.

CHIRURGIE UND RHEUMATISCHE KRANKHEITEN. By A. Fonio, M.D. Leipzig, 1939. Theodor Steinkopff.

This monograph gives an excellent survey on the theories, the anatomy, and the clinical pictures of the diseases of the joints except for those caused by infections such as tuberculosis, lues, gonorrhoea, purulent conditions and by neuropathology like tabes. The diseases of the joints with a syndrome analogous to chronic rheumatism but due to a different cause—Still's disease and tuberculous rheumatism (Grocco-Poncet)—have been described in detail. About ninety of the 220 pages are devoted to description of joint diseases of non-rheumatic origin. This includes the various types of arthrosis deformans, joint conditions in cretinism, hemophilia, juvenile osteochondritis and osteochondropathies, and metabolic diseases of the joints. The author's style and the few illustrations are good.

The origin of the title of the book is dubious, as there is practically nothing in the work relating to surgery or therapy of any kind.

OBSTETRICAL PRACTICE. By Alfred C. Beck, M.D. Second Edition. Baltimore, 1939. Williams & Wilkins. Price $7.00.

When Beck's book, presenting the essentials of obstetric practice to undergraduates and practitioners, came out four years ago, it was an instantaneous success. Within a year's time the edition was exhausted and a large second printing was necessary. Medical students, teachers and physicians found this text to their liking since it not only adhered to the strictly scientific throughout, but was readable as well. It made its points in no uncertain terms.

The new edition maintains these excellencies. The arrangement of content matter is logical. The section describing the mechanism of normal birth and abnormal deliveries is unique and original. Only a great teacher could have given us this presentation. Over 1100 drawings illuminate the text, and each one is necessary to make the point in question.

The extensive new work in the field of physiology has been included. Chapters on toxemia and abortion have been largely rewritten. The discussion of some of the complications of pregnancy is revised, and a chapter on retained and adherent placenta has been added.

The book as a whole is 858 pages long and is well indexed. It is undoubtedly one of the best texts on obstetrics now available in this country.

AN ATLAS OF SURGICAL OPERATIONS. By Elliott C. Cutler, M.D., and Robert Zollinger, M.D. New York, 1939. Macmillan. Price $8.00.

We do not know just where to bestow the greater praise: to Drs. Cutler and Zollinger for the plan and the text or to Miss Mildred B. Codding for the illustrations. All three have done their work admirably and have created one of the great classics of surgery.

The book itself is a large sized volume, 8½ by 12½ inches, which opens flat to show on each left hand page the description of a surgical procedure and on the facing right hand page the step by step technique illustrated masterfully. The broad surgical field is covered, so that the surgeon will find here every necessary detail. The surgical intern, resident or staff member may profitably consult this instructive work, since it is remarkably valuable and deserves the wide distribution it will undoubtedly receive.

THE STORY OF SURGERY. By Harvey Graham. New York, 1939. Doubleday, Doran. Price $3.75.

This book, on the literary side of medicine, can be of interest to layman and physician—surgeons especially will find it fascinating. Oliver St. John Gogarty tells us in his introduction that it is "the best book on surgery I have ever read." We feel sure others will echo this.

In over 400 pages, the entire history of surgery is surveyed from its earliest phases to the surgery of "today and tomorrow." Most of the facts are probably familiar to the well informed, but the author presents them in intriguing fashion. Once started, the book is difficult to put down.

THE PHYSIOLOGY AND PHARMACOLOGY OF THE PITUITARY BODY. Volume II. By H. B. Van Dyke. Chicago, 1939. University of Chicago Press. Price $4.50.

Reports on the functions and interrelationships of the pituitary run up into the hundreds

each year, and periodic summaries of the status of endocrine physiology are therefore not only desirable but necessary. Since 1934 research has been particularly active, advances have been noteworthy and confusion rife. Dr. Van Dyke has therefore rendered signal service to biology and medicine in taking the massive literature, digesting it and reporting the results. This volume represents the gist of the experimental and clinical literature on the pituitary which has appeared since 1935. We can think of no volume which matches it. To endocrinologists it probably represents required reading.

THE ORGANISM. By Kurt Goldstein, M.D. New York, 1939. American Book Company. Price $4.00.

This work, the result of years of observations, especially of soldiers with brain injuries, was made possible by the hospitality the author found in the Netherlands and the support of Dutch and American foundations. It is a holistic approach to biology derived from pathologic data in man. The volume is primarily addressed to the student of the biological sciences who is familiar with the technicalities of contemporary problems centering around the question: What solution can the recent controversies in the science provide as the adequate approach to organismic behavior? The present edition is essentially a translation of the German original, and constitutes a part of the American Psychology Series under the general editorship of Henry E. Garrett.

THE ART OF ANAESTHESIA. By Paluel J. Flagg, M.D. Sixth Edition. Philadelphia, 1939. J. B. Lippincott Company.

Paluel Flagg is nationally known for his work on the problem of asphyxia, especially as related to anesthesia. He also has evolved direct methods of artificial respiration—now known as the Meltzer-Flagg technique. Because of his efforts a Committee on Asphyxia was organized by the American Medical Association. He has contributed important articles on this subject in The American Journal of Surgery. This year he established a Department of Pneumatology in connection with the medical department of the World's Fair in New York. We recite these facts that the reader will get a slight idea of the author's background and work. This work is now a standard; this, the sixth edition, has been rewritten in parts and many new subjects and features added, bringing it up to date. To physicians who have anything to do with anesthesia and to nurse-anesthetists, Dr. Flagg's book is a necessity.

CANCER HANDBOOK OF THE TUMOR CLINIC OF STANFORD UNIVERSITY SCHOOL OF MEDICINE. Edited by Eric Liljencrantz, M.D. San Francisco, 1939. Stanford University Press. Price $3.00.

The methods of cancer diagnosis and treatment outlined in this handbook are founded on present practices at the Stanford University Tumor Clinic and represent the integrated experience of all its active members. It is in miniature a graduate course, elementary enough for any medical practitioner, yet complete enough to prepare and enlighten him for the proper handling of his cancer patients.

The book is limited to 114 pages, has fifty figures, an extensive bibliography and an index. Radiation therapy, the treatment of cancer in various organs, nervous system tumors, the leucemias and other subjects more or less allied, are discussed.

OTOLARYNGOLOGY IN GENERAL PRACTICE. By Lyman G. Richards, M.D. New York, 1939. Macmillan. Price $6.00.

The usual manual of ear, nose and throat diseases is designed for the specialist in that field. Dr. Richards, on the other hand, has planned his otolaryngology for the general practitioner. In view of the fact that about 20 per cent of a general practice consists of work in this branch of medicine, such a manual fills a long-felt want.

In line with his purpose, details of surgical procedures have been omitted, since these would normally fall within the province of a consulted specialist. Chief emphasis has been placed on the ordinary procedures of examination and diagnosis, with treatment of the conditions commonly seen. The significance and therapy of pain or discharge in the ear, deafness, sore throat, epistaxis, hoarseness, cough, dysphagia and headache are discussed. The technique of tonsillectomy, adenoidectomy, intubation and tracheotomy is given since these are procedures which any practitioner will need to have at his command.

The illustrations are planned from the same point of view—they are simple and diagrammatic, showing procedures to be accomplished and the manner in which they are carried out.

Though the specialist will find little grist here for his mill, the general practitioner will find the book a valuable aid.

TREATMENT BY MANIPULATION. By A. G. Timbrell Fisher, F.R.C.S. Third Edition of "Manipulative Surgery." New York, 1939. Hoeber. Price $3.75.

This book, now offered in a third edition, was written with the object of drawing the attention of the medical profession to the importance and value of manipulative treatment in certain selected cases, particularly in the sequelae of injuries and diseases affecting the joints, muscles, tendons, and fasciae. This edition has new chapters on the cult of osteopathy and the prevention of adhesions, and a number of new illustrations. It is a sanely written monograph of 255 pages, which will be of value to those who have employed this form of treatment and to those who may find uses for it now that it is brought to their attention.

MATERNAL CARE AND SOME COMPLICATIONS. Edited by F. L. Adair, M.D. Chicago, 1939. University of Chicago Press. Price $1.50.

This small book of 194 pages could well be assigned as compulsory reading for every general practitioner who "does obstetrics." Marked improvement in the handling of the pregnant woman would be bound to result.

Section I of the little text deals with maternal care, section II with complications such as emesis and toxemia, hemorrhage and puerperal infection.

The style is delightful, the subject matter well handled and the whole book well worth the time spent in its preparation.

GYNECOLOGIC OPERATIONS AND THEIR TOPOGRAPHIC ANATOMIC FUNDAMENTALS. By Heinrich Martius, M.D. Translated under the editorial supervision of W. A. Newman Dorland, M.D. Chicago, 1939. S. B. Debour. Price $10.00.

The other evening the reviewer entertained his staff of residents, interns and younger assistants. They chanced upon this book in a stack awaiting review, and their enthusiasm was instantly aroused.

One does not learn to operate from a book—that goes without saying—but a book which depicts clearly the steps of the various gynecologic procedures is a definite help. The text here is concise and clear since the translators have done a creditable job. The illustrations, most of them in color, could hardly be finer. They are done so well that the point gets across immediately to the reader. To the young man interested in operative gynecology, this is a good purchase to recommend.

THE MECHANISM OF THOUGHT, IMAGERY AND HALLUCINATION. By Joshua Rosett, M.D. New York, 1939. Columbia University Press. Price $3.00.

This short book reveals for the first time the foundations of the three primary mental functions. It covers the evolution and dissolution of the nervous system, the emotional state, the relation of the emotions to the conscious, sensory or informative state, the expression of subjective experience of emotion, will, nerve signalling and the representation of symbols. A second section deals with the mechanism of thought, imagery and hallucination, with injuries and diseases of the nervous system and with the phenomena of attention and sleep. Each chapter is concluded with a summary and a list of references, and the book as a whole is indexed.

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